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THE COMPOUND AND MIXED NESTS OF AMERICAN ANTS.

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PART II (*continued*).

V. DULOSIS.

UNDER this heading we may include all those remarkable mixed nests which owe their origin to the enslavement of one species of ant by another. This condition is characterized by Wasmann ('91, p. 43) as follows: "Here ants of different species dwell together, not only on the same spot, but coalesce to form one colony, a single social whole. In such communities the unity of the colony is of paramount importance, and the specific differences between the various components of the colony lapse so far into abeyance that they appear to be non-existent; the consociating ants, belonging originally to different nests, behave towards each other as if they were kith and kin, and carry on in common the construction of the nest, the acquisition of food, the education of the offspring, the defense of the nest, etc., so far as this is permitted by their physical and psychical endowments and the law of the physiological division

of labor. Hence the term 'slaves' is much less appropriate than the term 'helpmates' (auxiliaries)."

While the various forms of social symbiosis hitherto considered may exist between ants belonging to very different taxonomic subfamilies, dulosis is known to occur only between species of the same subfamily. This rule is based on but few cases, for only four genera, two belonging to the Camponotinæ and two to the Myrmicinæ, *viz.*, Formica, Polyergus, Strongylognathus, and Tomognathus, are known to contain dulotic species. Still it seems obvious that such close symbiotic relationships as those under consideration could be entered into only by species of very similar habits and phylogenetic derivation.

With the exception of Strongylognathus, the above-mentioned genera are all known to occur on our continent, the dulotic species of Formica (*F. sanguinea* Latr.) and Polyergus (*P. rufescens* Latr.) being represented by distinct races, or subspecies, the genus Tomognathus by a distinct species (*T. americanus* Emery). So little attention, however, has been devoted to our ants, that we may yet look forward to the discovery of an American Strongylognathus, for there are in America several species of the genus Tetramorium (including the subgenus Xiphomyrmex) which are allied to the *Tetramorium cæspitum* auxiliary of the European Strongylognathus.

The meagre work which has been done on our American dulotic ants is barely sufficient to show that their behavior is essentially like that of their European allies. Since these ants in America select their auxiliaries, or slaves, from a slightly different though allied ant fauna, we may yet expect to find some interesting differences in the details of habit and behavior.

Before enumerating the American species, together with their auxiliaries, it will be convenient to present a much condensed résumé of the splendid accounts of the European observers, Forel, Wasmann, and Adlerz.

Formica sanguinea Latr. — This species is a true Formica, which is sometimes found living without auxiliaries. It has broad, toothed mandibles, of the type characteristic of its

genus, and is naturally carnivorous, though it has been observed to attend aphides for the purpose of collecting their sugary excrement. Although this ant is, therefore, quite able to exist alone, it nevertheless has a very pronounced *penchant* for robbing the larvæ and cocoons of other species of Formica, eating great numbers of them but allowing others to develop and to function as its slaves, or auxiliaries. The latter feel themselves to be members of the colony in which they emerge from their cocoons, and direct all their activities to maintaining and defending their foster nest and its occupants. In Europe, as a general rule, the normal slaves of *F. sanguinea* are the workers of *F. fusca*, less frequently the workers of *F. rufibarbis*. Sometimes both species of auxiliaries may be found in the same mixed nest. In extremely rare instances the workers of *F. rufa* and *F. pratensis* may serve as slaves. The expeditions for robbing cocoons are usually carried out during July and August, but they seem to be rather infrequent or irregular and are not often observed. The tactics of *F. sanguinea*, like those of other dulotic ants, consist in surprising the colony they wish to rob and in carrying away the pupæ as rapidly as possible without engaging in unnecessary slaughter. Only the ants that offer active resistance are dispatched.

F. fusca is most frequently enslaved because it is a weaker and more tractable species and forms smaller colonies than *F. rufibarbis*. The rare occurrence of *F. rufa* and *pratensis* in *sanguinea* nests is due to the more savage nature of these species, which are enslaved only when they belong to small colonies or when they are of small size individually.

The number of auxiliaries in nests of *sanguinea* varies greatly. In Holland, in more than 100 nests, Wasmann ('91) found the ratio of *sanguinea* to slaves varying between 1:0 and 1:3. Most frequently the *sanguinea* are from 2 to 5 times as numerous as their slaves. The number of the latter depends on various circumstances, such as the abundance or scarcity of nests of the auxiliary species in the vicinity. It is a singular fact that the weakest colonies of *sanguinea* contain the greatest number of slaves, so that it would seem as if the dominant species tried to make good the deficiency in the

number of its workers by importing and employing foreign labor. This may result naturally from the fact that in weak colonies on an average a larger percentage of the stolen pupæ are permitted to develop into slaves. In populous *sanguinea* colonies, on the other hand, a considerable portion of the prey is devoured even when there is plenty of other insect food within reach.

The relations implied by the terms "slave" and "master" do not adequately express the conditions existing in these mixed nests, since *sanguinea* works side by side with its auxiliaries, which are neither a mere luxury nor an absolute necessity. Still, although *sanguinea* is capable of excavating and maintaining its own nest, the auxiliaries appear to be more enthusiastic and skillful workers in the earth. And although *sanguinea* looks after its own brood and the hatching of the cocoons of the auxiliary species, it must, nevertheless, derive some advantage from the assistance of its slaves. The latter, moreover, bring into the nest a good deal of food from the aphides, which they assiduously attend.

F. sanguinea, on moving to a new nest, usually carries its slaves, and is rarely carried by them. This is probably due to the fact that the *sanguinea* are of a more excitable temperament and therefore have a greater tendency to take the initiative in a change of dwelling than their more stolid auxiliaries.

Continental authorities uniformly maintain that the *sanguinea-fusca* nests contain only workers of the auxiliary species. In England, however, Rev. T. D. Morice ('00, p. 98) recently found a nest which contained also *fusca* males and queens in addition to the workers of this species. This very exceptional condition would seem to have arisen either from the failure of the *sanguinea* to consume all the pupæ of the fertile sexes of *fusca*, or less probably from the formation of an alliance colony between fertile queens of *sanguinea* and *fusca*.

Polyergus rufescens Latr. — The "amazon," as the paragon of dulotic ants, has been observed with great care by a number of investigators, among whom Pierre Huber ('10) and Forel ('74) hold the first place. It is a rather large, brown-red ant, allied to Formica, but characterized by the possession of slender,

sickle-shaped mandibles, the cutting edges of which are furnished with minute serrate teeth. Such mandibles are beautifully adapted to fighting, but scarcely fitted for the many other uses to which these organs are put by most ants. Polyergus is therefore a warrior, and on this account its life presents two very different phases, one replete with the brilliant tactics whereby it gains possession of the larvæ and cocoons of its

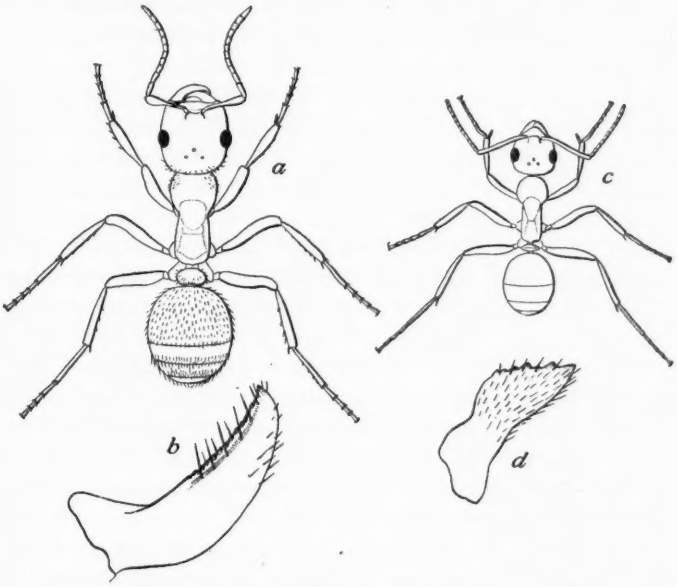


FIG. 15. — *a*., *Polyergus rufescens* Latr., subsp. *breviceps* Emery, worker; *b*, mandible of same; *c*., *Formica fusca* L., var. *subsericea* Say, subvar.; *d*., mandible of same.

slaves, the other characterized by abject helplessness and complete dependence on these same auxiliaries.

The auxiliaries of Polyergus are furnished by the very same species as in the case of *F. sanguinea*. In this case, also, *F. fusca* is most often victimized, *rufibarbis* less frequently. Occasionally, too, both species are found in the same nest. The number of slaves, however, is much greater than in *sanguinea* nests, being about seven-eighths of the entire colony. The dulotic expeditions of Polyergus have been often observed

since the days of Pierre Huber ('10, p. 210 *et seq.*). They have been admirably described by Forel ('74), who has also estimated (pp. 320, 321) the number of expeditions undertaken by a single powerful colony of these ants during a single summer. In thirty days (from June 29 to August 18, 1873) he witnessed forty-four expeditions of the amazons. These usually occurred between 2 and 5 o'clock P.M., the time limits being from 1.30 to 6 P.M. Among the forty-four expeditions there were forty-one attacks, nineteen on *fusca* and nineteen on *rufibarbis*, and three of which only the return was observed. The total number of cocoons robbed was estimated at 29,300 (14,000 *fusca*, 13,000 *rufibarbis*, and 2300 of unknown origin but probably *fusca*). Counting in the expeditions after August 18, which he was unable to witness, Forel concludes that not far from 40,000 larvæ and pupæ of the auxiliary species were appropriated during the summer of 1873 by a single Polyergus colony ! Most of the pupæ were consumed, so that few of them ever hatched and became auxiliaries. And although two species were pillaged the colony later became almost entirely *F. fusca*.

Wasmann ('91, pp. 61, 62) has observed that the *fusca* auxiliaries are noticeably fiercer and more courageous than when nesting alone. The same is true of *fusca* in *sanguinea* nests. This is explained by Wasmann as merely a special case of the general rule that all ants are more courageous when they feel themselves backed by numbers.

The shadow side of the life of Polyergus is seen within its nest, where it is abjectly dependent on its slaves. Here it spends most of its time preening its legs and antennæ, as it is quite unable to excavate. On this account the character of the nest architecture is entirely determined by the auxiliary species. Moreover, the conformation of its mandibles is such that Polyergus cannot care for its own young or the pupæ of its slaves, though it sometimes licks the newborn callows. After a minute investigation of the question as to whether Polyergus is able to feed itself, Wasmann concludes that it can lap up liquids but is usually fed by the slaves. This mode of obtaining its food is, in fact, so essential, that it dies of starvation when deprived of its helpmates.

Polyergus goes on its cocoon-robbing expeditions unattended by its auxiliaries. When the colony moves to a new nest the Polyergus are nearly always carried by their slaves (*cf. F. sanguinea!*). In this case the slaves commonly initiate the change of dwelling. At home the Polyergus appear to be under the guardianship of their slaves and to be treated like helpless dependents. They are sometimes even held back from their sorties by the auxiliaries.

The way in which the fertilized Polyergus queen starts her colony has not been observed. Forel and Wasmann have demonstrated that a friendly alliance may be easily effected in artificial nests between Polyergus queens and strange workers of *F. fusca*, and Wasmann concludes from this fact that new mixed colonies may be started by such consociations under natural conditions. But it does not appear to be necessary to accept this inference. The fertilized Polyergus queen may be quite as well able as other queen ants to raise unaided an incipient colony of small workers which could then pillage adjacent nests of *fusca* and provide themselves with the necessary auxiliaries. It has, moreover, been observed that Polyergus queens occasionally accompany the workers on their raids, and this habit may be still more pronounced in the queens of incipient colonies. I deem this probable because the young queens of other species very generally perform nearly all the functions which are later delegated more or less completely to the workers alone.

Tomognathus sublævis Mayr (Fig. 16). — This is a small, rather hairy ant, with broad and edentulous mandibles. It occurs only in northern Europe (Finland, Sweden, and Denmark). Two very careful studies of its habits have been published by Adlerz ('86 and '96). The auxiliaries are furnished by *Leptothorax acervorum* or *L. muscorum*, more rarely by *L. tuberum*. Adlerz's observations show that the Tomognathus secure these auxiliaries by attacking a Leptothorax colony, driving away the ants, and taking possession of the nest, together with the larvæ. The latter are then reared as helpmates. It is probable, however, that the Tomognathus may occasionally recruit the number of their slaves by making

sorties like Polyergus, for Adlerz succeeded in finding a nest of Tomognathus with two species of auxiliaries (*L. acervorum* and *muscorum*).

The mixed nests of Tomognathus-Leptothorax may contain males, queens, and workers of both the dominant and victimized species, a condition not known to occur in the case of other dulotic nests. The males of Tomognathus (Fig. 16, *a*) resemble the males of Leptothorax so closely that Adlerz failed

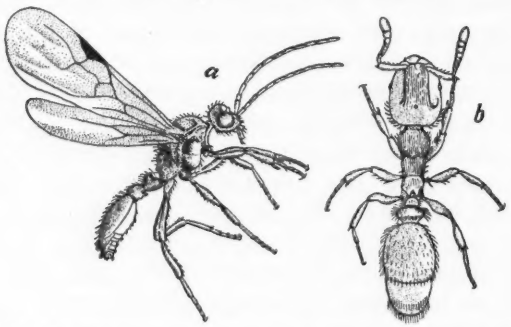


FIG. 16. — *Tomognathus sublævis* Mayr (after Adlerz); *a.*, male; *b.*, female (ergatoid).

to distinguish them till he published his second study ('96). The female is also of such a remarkable character that it, too, was originally overlooked. This sex is apterous (Fig. 16, *b*) and resembles the worker except in possessing ocelli and a receptaculum seminis.

The industrial instincts of Tomognathus are very rudimentary. It rarely or never excavates. It is able to feed itself if food is within reach, but it does not go in quest of provisions. This it leaves to the Leptothorax auxiliaries, by whom it is usually fed. Occasionally it may be seen caring for the larvæ. A number of Tomognathus which were isolated with larvæ and some food managed to live for 135 days, but the larvæ died or shriveled up. It seems probable, therefore, that Tomognathus depends on its slaves to a certain extent even for the care of its larvæ. When the colony is compelled to move to a new nest, the Tomognathus are usually deported by the Leptothorax; only rarely are the rôles reversed.

Sometimes when they desire to leave the nest, the Tomognathus are detained by the auxiliaries in much the same manner as Polyergus.

The males of Tomognathus do not mate with the females of the same nest, but do so readily with the virgin queens of other nests. The larvæ are so similar to those of the Leptothorax that Adlerz was unable to distinguish them. They are nourished with both liquid and solid food. Adlerz's description of the manner in which the larvæ are fed with pieces of flies tallies exactly with my observations on the primitive method of feeding adopted by the Ponerinæ and the Myrmicinæ of the genera Stenamma (Aphænogaster) and Pheidole ('00[a] and '00[b]).

Strongylognathus. — The species of Strongylognathus have perfectly edentulous, falcate mandibles, and more or less projecting postero-lateral corners to the head. Four species of the genus are known to occur in Europe: *S. huberi* Forel, *S. testaceus* Schenk, *S. christophi* Emery, and *S. cæciliæ* Forel. The habits only of the first two have been observed (Forel, '74 and '00[a]; Wasmann, '91), and these present interesting differences. Both species form mixed nests with *Tetramorium cæspitum: S. huberi* in southern Europe and northern Africa, and *S. testaceus* in southern and central Europe.

S. huberi seems like a diminutive and feeble caricature of Polyergus. Forel ('74) found by experiment that it would rob the larvæ and pupæ of Tetramorium and fight with the rightful owners after the manner of Polyergus. But it is not known whether *S. huberi* under natural conditions really provides its nests with auxiliaries by carrying on regular marauding expeditions. Forel, in a more recent paper on this species ('00[a], p. 275), expresses the opinion that it may not make sorties but keep up the mixed colony by alliance with the Tetramoriums instead. The workers of Strongylognathus are able to excavate, but they are fed by the Tetramorium workers. The latter are present in considerable numbers in the mixed nests, but up to the present time fertile queens of Tetramorium have not been found with them, though from what is known of *S. testaceus* one or more of these queens may perhaps be present in some cases.

S. testaceus is a commoner and better known form than *S. huberi*, and is supposed to represent a further advance towards a condition of social parasitism. The number of workers of *S. testaceus* is decidedly smaller in proportion to the number of Tetramoriums. On this account Forel maintains that the worker cast of *S. testaceus* is on the road to disappearing (*cf.* Anergates !). As fighters these workers, though provided with sabre-like mandibles, are indeed but sorry caricatures of Polyergus and decidedly less valiant than the workers of *S. huberi*. They do not kill the Tetramoriums, but seem to frighten them into deserting their larvæ and pupæ. Their weakness is further shown by the fact that they do not undertake their pillaging expeditions alone, but accompanied by their Tetramorium auxiliaries, and it is these latter that determine the success of the enterprise undertaken for the sake of robbing their own species. The workers of *S. testaceus* are even awkward in their attempts to carry away the conquered larvæ and pupæ. Although the Tetramorium auxiliaries commonly do all the work within the nest, such as excavating the galleries, caring for the larvæ and pupæ, and feeding the Strongylognathus, the latter are, nevertheless, able to feed themselves and to dig the nest, but they are apparently unable to care for the young.

Forel and Wasmann have succeeded in throwing considerable light on the obscure problem of the origin of the *S. testaceus*-Tetramorium colonies. The former found a single fertile queen of the Strongylognathus living amicably in the midst of a colony of *Leptothorax acervorum;* and Wasmann made the significant discovery of a fertile queen of the Strongylognathus and a fertile queen of Tetramorium living side by side in the same nest. This nest contained workers of both species (15,000–20,000 Tetramoriums and some thousands of Strongylognathus), and pupæ, about 70% of which were males and females of Strongylognathus. The remainder included two large male pupæ of Tetramorium. From this discovery Wasmann infers that the mixed nests of *S. testaceus*-Tetramorium are alliance colonies brought about by the adoption of fertilized queens of Strongylognathus by Tetramorium colonies.

The fact that these mixed nests rarely contain male Tetramoriums and never, so far as known, queen pupæ of this species, is explained by Forel ('00[a], p. 273) as the result of a general regulative instinct: "The females and males of Strongylognathus are smaller and less troublesome to nourish. This is obviously sufficient to induce the Tetramorium workers to rear them in the place of their own enormous queens and males, the larvæ of which they therefore undoubtedly devour or neglect, as they do in the case of all that seems to be superfluous."

After this brief review of the European species we may turn to our American dulotic ants.

16. **Formica sanguinea** Latr., subsp. **rubicunda** Emery.

Although the typical *F. sanguinea* is not known to occur in America, the species is, as Emery has shown ('93[a], p. 647), far more variable on this continent than it is in Europe. We should therefore be prepared to find a corresponding variability in its instincts, though this may not be commensurate with its taxonomic variation.

F. sanguinea is also occasionally found without slaves in America, but far more frequently it is attended by ants belonging to the great group of forms which centers about *F. fusca*. The best known subspecies of *F. sanguinea* in the Northern and Atlantic States is undoubtedly *rubicunda*. This is usually found with slaves belonging to *F. fusca*, var. *subsericea* Say, but one colony which I observed near Rockford, Ill., Sept. 16, 1900, contained about equal numbers of auxiliaries belonging to two species, *viz.*, *F. pallide-fulva* Latr., subsp. *nitidiventris* Emery, and *F. fusca*, var. *subænescens* Emery.

The above assumption that the habits of *F. sanguinea* in America may differ to some extent from those of the European form seems to be borne out by some recent observations of Forel ('00[c], pp. 11–12). Owing to Forel's long and very intimate acquaintance with the European *sanguinea*, these observations on our American form are of great value. He had occasion at Cromwell, Conn., to witness the attack of a very

small troop of *F. sanguinea* (probably *rubicunda*) on a large formicary of *F. subsericea.* "There were scarcely thirty *F. sanguinea*, and a third of these were recently hatched workers, still immature. The troop was evidently from an incipient colony. The *subsericea* had their nest about the roots of a great mullein (Verbascum). Their numbers were at least ten times as great as that of their assailants, and it may be admitted that each of them was fully as well armed and on the average larger and more robust than the *sanguinea.* Well, the mere arrival of the little troop of *sanguinea* sufficed to spread consternation through the nest of the *subsericea*, which betook themselves to flight with their larvæ and pupæ, but permitted the *sanguinea* to snatch these away and to conquer their nest without even making a serious show of defending themselves. Not more than one or two small *sanguinea* were killed in the fray. This fact is of importance, for in this instance we cannot allege the redoubtable weapons, hard integument, or even the impetuosity of the analogous attacks of the little troops of *Polyergus rufescens* which I have described in my 'Fourmis de la Suisse.' The bold and courageous tactics of the *sanguinea* were even less noticeable than in the European form of this species, which wages war on smaller and more feeble species than itself. I have never yet seen such complete and absurd cowardice as that of the American *subsericea*, a cowardice which brings clearly into prominence the instinctive adaptation to attack on the part of the enslaving, and to flight on the part of the enslaved species."

At Colebrook, Conn., during August, 1900, I had an opportunity to see a colony of *rubicunda* moving to a new nest. Each of the ants was carrying a motionless, curled-up *F. subscricea* in its jaws. The rather open phalanx of ants presented a very striking appearance as it moved from a shady hedge where the old nest was located, across a dusty road and disappeared in the undergrowth of a wood on the opposite side.

17. **Formica sanguinea** Latr., subsp. **rubicunda** Emery, var. **subintegra** Emery.

This variety, originally found by Mr. Pergande in the District of Columbia, has the same slave as the preceding, *viz.*, *F. subsericea*. During July, 1900, I found a very large nest of this variety on Naushon Island, Mass. It contained the usual auxiliaries and was compounded with a large nest of *Solenopsis molesta*.

18. **Formica sanguinea** Latr., subsp. **rubicunda** Emery, var. **subnuda** Emery.

This form was discovered by Mr. Dieck near Yale, D. C. Its auxiliaries are also furnished by *F. subsericea*.

19. **Formica sanguinea** Latr., subsp. **puberula** Emery.

This small form, which occurs in Colorado, is probably the one observed by McCook ('82, pp. 152–153). Its auxiliaries, according to this observer, belong to *F. schaufussi* and to a small black species (probably one of the western varieties of *F. fusca*).

20. **Formica sanguinea** Latr., subsp. **obtusopilosa** Emery.

Emery described this subspecies from New Mexico. Its auxiliary is not recorded, but is probably furnished by some variety of *F. fusca*, like *neorufibarbis* Emery or *neoclara* Emery.

21. **Polyergus rufescens** Latr., subsp. **lucidus** Mayr.

P. lucidus, the "shining slave-maker" of McCook, is the best known of the three American subspecies. It has been taken in several of the Atlantic States from Cape Cod to North Carolina and westward into Pennsylvania, but its exact geographical distribution has not yet been determined. Rev. P. J. Schmitt has sent me specimens from New Jersey, Maryland, and North Carolina. The specimens from the last-mentioned locality are decidedly opaque, thus resembling the European

form much more closely than do the typical specimens from other localities.

The habits of *P. lucidus* were first observed by McCook fully twenty years ago ('80). His account is fragmentary and barely sufficient to show that the habits are essentially like those of the European form. In the nest which he observed the slaves belonged to *F. pallide-fulva*, subsp. *schaufussi*. The same slaves were observed in a mixed nest taken on Cape Cod by Mrs. Mary Treat (Mayr, '86, p. 424). According to Pergande's observations cited by Wasmann ('94, p. 164), *F. pallide-fulva*, subsp. *nitidiventris*, is the auxiliary species in the District of Columbia. In the case observed by McCook it was, of course, the *F. schaufussi* which determined the character of the nest, since Polyergus does not excavate. Hence the title of McCook's paper is misleading. His observations on the feeding habits of *P. lucidus* are, as he remarks, "chiefly confirmatory of those recorded by Huber, Forel, and others in the European Polyergus." These, and a few additional notes on the belligerent disposition of this ant, are not, however, sufficient to leave no doubts in our minds that "our American species has precisely the same habit" of carrying on its dulotic expeditions, which he did not observe. Its slaves are certainly somewhat different in this country, and it is therefore to be presumed that the military tactics of the dulotic species may also be different.[1]

To McCook's inapposite criticism of Darwin's views concerning the phylogenetic origin of dulosis, I shall have occasion to return in the sequel.

22. **Polyergus rufescens** Latr., subsp. **breviceps** Emery.

This subspecies (Fig. 15, *a*, *b*), founded on specimens from South Dakota and Colorado, resembles the European *rufescens* still more closely than does *lucidus*, since it has the same sculpturing, opacity, and pilosity. It is, however, somewhat smaller, with a relatively shorter head, and its antennal scape is distinctly enlarged towards their tip. *P. breviceps* is evidently the form observed by McCook ('82, p. 384) in the

[1] *Cf.* the above-quoted observations of Forel on the American *F. sanguinea*.

Garden of the Gods. The slaves, according to McCook, belonged to *F. schaufussi*. Recently Rev. P. J. Schmitt has sent me specimens of *P. breviceps* from Breckenridge, Col. In this case the slaves accompanying the specimens belong to a rather small, monticolous subvariety of *F. subsericea* (Fig. 15, *c*, *a*).[1]

23. **Polyergus rufescens** Latr., subsp. **mexicanus** Forel.

This Mexican subspecies (Forel, '**99**, p. 129) is related to *breviceps*, but is larger, and without pubescence on the upper surface of the body. The exact locality of Forel's specimens is not given. It is safe to say that they must have been taken somewhere on the high plateau of central or northern Mexico. The auxiliary species is not recorded, but it is probable that the varieties of *F. fusca* (*F. subsericea* and *F. neorufibarbis*) recorded from the Mexican plateau (Forel, '**99**, p. 128) furnish the requisite slaves.[2]

24. **Tomognathus americanus** Emery.

This species (Fig. 17), which is both smaller and in other respects quite distinct from the European *sublævis*, appears to be very rare. The type specimens were taken by Mr. Pergande at Washington, D.C., in a nest of *Leptothorax curvispinosus* Mayr (Fig. 18), but no observations on the mutual relations of the two species were recorded. Rev. P. J. Schmitt of Beatty, Pa., writes me: "I have taken this species on but one occasion, — when I carried home a bushel of sifted vegetable matter from the woods. On examining this carefully

[1] While this article was going to press I discovered a fine large colony of *P. breviceps* in some woods near Rockford, Ill. The ants with their slaves — in this instance *Formica fusca* L., var. *subænescens* Emery — were living in a rotten stump in cavities excavated and long since abandoned by *Camponotus pennsylvanicus*. The Polyergus workers, like the Colorado specimens, are of small size with distinctly club-shaped antennal scapes. The head and thorax are opaque and the hairs on the abdomen are long and projecting. The abdomen is shining and nearly black in color.

[2] Buckley ('**66**, p. 170) describes a black female ant from Texas as *Polyergus texana*, but no one has since succeeded in recognizing this species. It is probably not a Polyergus at all.

I found about a dozen of the ants, which were readily recognized as Tomognathus. There may have been a few Leptothorax in the material,—certainly very few, if any,—but when

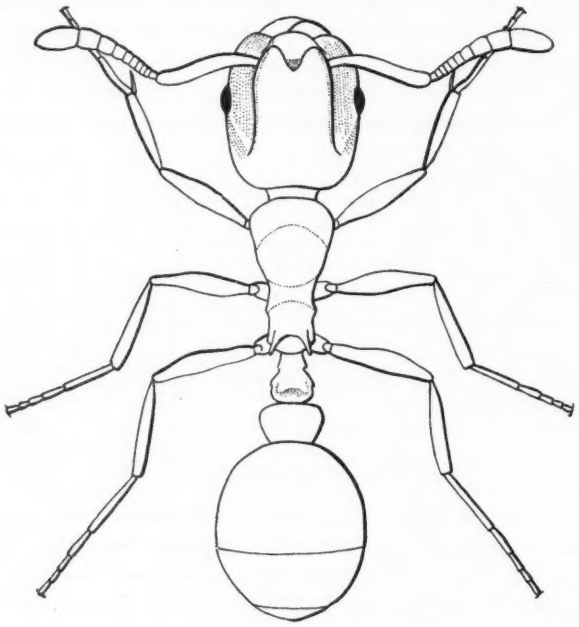


FIG. 17.— *Tomognathus americanus* Emery. Worker.

collecting with the sieve it is hazardous to affirm that any ants that are found belong to mixed or to independent colonies."

VI. COLACOBIOSIS.

It is very difficult to establish a clear distinction between the ants of this and the preceding category, since Strongylognathus is obviously transitional. Forel even includes this genus among the social parasites, while Wasmann includes the whole of Forel's category among the forms which I have designated as dulotic. I believe, however, that I am justified in erecting a special category for Anergates, which is the only well-known

social parasite, and for the American *Epœcus pergandei*, since these forms have become so extremely dependent on ants of other species that they have even lost the worker caste, thus leaving the species to be represented only by the fertile sexes like the vast majority of living organisms. The following condensed account of the work of European observers on *Anergates atratulus* is translated from Janet ('**97**, p. 58 *et seq.*), who incidentally adds to it some valuable observations of his own:

Anergates atratulus is a very bizarre ant, which inhabits central and northern Europe. It has been studied by Schenck ('**52**),

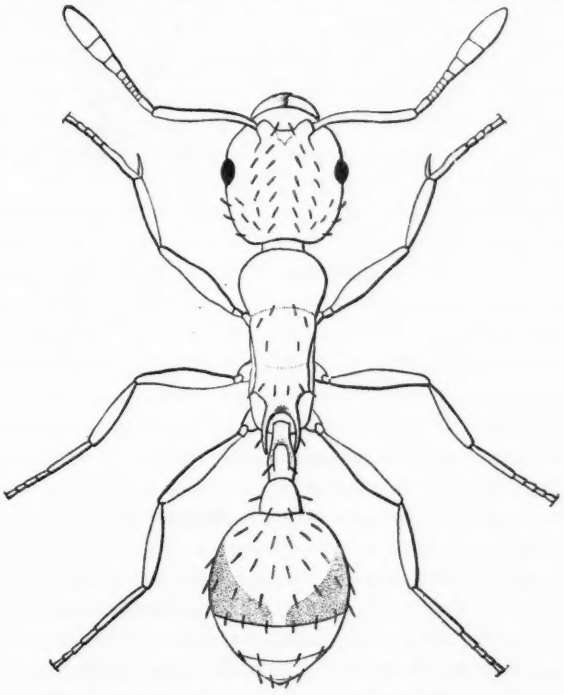


FIG. 18. — *Leptothorax curvispinosus* Mayr. Worker.

von Hagens ('**67**), Forel ('**74**), Adlerz ('**86**), and Wasmann ('**91**). As indicated by its name, it is a species which possesses no worker form. At the time of hatching from the pupa the

female presents very nearly the normal shape of queen ants and possesses wings. After fecundation, however, owing to an extraordinary development of the ovaries, her abdomen takes on the appearance of a sphere 4 mm. in diameter (Fig. 19, *b*), on which are seen in the form of little plates, isolated by the distention of the articular membranes, the strongly chitinized rings which constitute the whole external surface of the abdomen in the young individual (Fig. 19, *c*). The male (Fig. 19, *a*) is apterous, and its abdomen is strongly curved downwards. He has a dawdling gait. The strigil is well developed in the

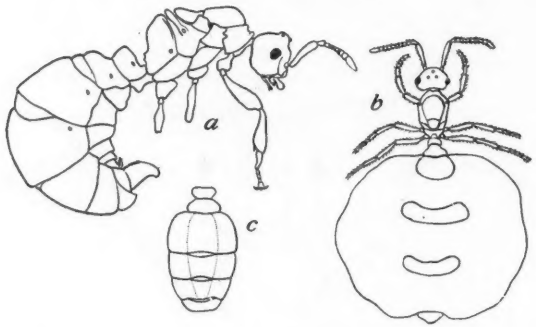


FIG. 19.— *Anergates atratulus* Schenck. *a*., male (after Adlerz); *b*., fertile female (after Forel); *c*., abdomen of virgin female (after Adlerz).

female, while in the male it is very small, but nevertheless pectiniform in certain specimens (Switzerland, Forel), although in others it lacks the teeth and is quite rudimental or even almost obsolete (Sweden, Adlerz; Holland, Wasmann; Beauvais, Janet).

In some young male specimens collected at Beauvais and preserved in alcohol, I observed by transmitted light, in the head, near the eyes, and of about the same size as these, the two mandibular glands and their excretory ducts opening at the base of the mandibles. These glands are therefore well developed, notwithstanding the fact that the mandibles, which are rounded at their tips, are much reduced. The male and female are both provided with well-developed ocelli. The antennæ are 11-jointed in both sexes.

Owing to the absence of wings in the males, mating takes place within the nests. This can be easily observed both in the natural and in the artificial nests. The couples may be killed without separating, by immersion in warm alcohol.

The nuptial flight of the females was observed by von Hagens ('**67**) on the 12th of August in the Rhine province. Some of the queens may perhaps fly to other nests and there be fertilized, and although there is usually only one fertile queen to a colony, it is possible that there may occasionally be several originating from different nests. If this were not the case we should have the condition to which Forel has called attention ('**74**, p. 343), *viz.*, that all mating must necessarily take place between brothers and sisters of the same colony.

The missing workers of *Anergates atratulus* are replaced in the mixed colonies by the workers of *Tetramorium cæspitum*. Whatever progeny is found in these colonies belongs exclusively to the Anergates. The Anergates of both sexes are nourished with food regurgitated from the mouths of their Tetramorium auxiliaries. They appear to be incapable of obtaining their food in any other manner.

Adlerz ('**86**, p. 231) and Wasmann ('**91**, p. 136) have ascertained that the Tetramorium auxiliaries of the Anergates pay relatively little attention to the young queens, while, on the other hand, they very frequently carry the males about and lick them long and assiduously. During this operation the males assume a characteristic motionless attitude. The two authors compare the attention thus bestowed on the male Anergates by the Tetramorium auxiliaries to that bestowed on myrmecophilous beetles that secrete certain substances of which the ants appear to be fond; *e.g.*, the attention bestowed on *Claviger testaceus* by *Lasius flavus*.

Adlerz and Wasmann have made experiments with a view to determining the method whereby a new mixed colony is formed, *i.e.*, by the association of the female Anergates with the Tetramorium workers. Adlerz ('**86**) in Sweden placed several unfertilized Anergates queens in a strange nest of Tetramorium. They moved about among the Tetramorium as if unperceived. He obtained nearly the same results on placing unfertilized

queens of Anergates in a normal colony of Tetramorium comprising a queen and her progeny. He also placed a considerable number of the larvæ, pupæ, and male and female imagines of Anergates in a normal colony of Tetramorium which were living in an artificial nest. In all cases the strangers were almost at once amicably received. Wasmann ('**91**, p. 142) obtained similar results in Holland. He observed that strange Tetramoriums did not in the least injure the male or female Anergates which he gave them, whereas they killed without mercy the *Strongylognathus testaceus* males or females that were placed in their nest. I have reported an experiment made on the same subject ('**96**, p. 27). I have also performed the following experiment: A normal colony of *Tetramorium cæspitum* provided with a deälated queen, and a normal colony of Anergates comprising an obese queen, some slender young queens, some males and some Tetramorium workers — both colonies comprising about the same number of individuals — were put together in an artificial nest. There ensued some struggles of relatively little importance, but some days later the obese queen was found lying dead in the midst of a cluster of Tetramoriums which seemed to be caring for her assiduously. Some weeks later all the Anergates males and females had disappeared, so that the colony again became a normal colony of Tetramorium. Von Hagens ('**67**) kept a single formicary of Anergates under observation during several consecutive years in the same place. It is difficult to assume that the number of Tetramoriums may be maintained in an Anergates colony by the introduction in one way or another of newcomers, so that I am inclined to believe with Wasmann ('**91**, p. 143) that the duration of such a colony is limited to the duration of the life of the Tetramoriums.

25. **Epœcus pergandei** Emery.

Emery ('**94**, p. 274) believes that this species, like Anergates, has no worker forms. Up to the present time it has been taken only once, when Mr. Pergande found it in a nest of *Monomorium minutum* Mayr, var. *minimum* Buckley, near Washington, D. C. This nest contained not only the winged

males and females of the parasitic species, but was also provided with the winged sexes of the Monomorium. When both species were put together in the same vial the Epœcus queens attacked and killed some of the males of Monomorium. These meagre data constitute all the forthcoming evidence for supposing that the habits of Epœcus are analogous to those of

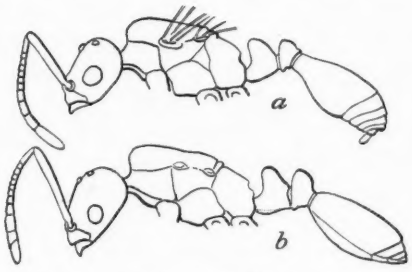


FIG. 20. — *Epœcus pergandei* Emery (after Emery). *a*., male; *b*., female.

the European Anergates. I may add that I have examined many dozens of *Monomorium minimum* nests in Texas in the hope of finding their rare parasite, but up to the present time my search has been in vain.

VII. SYNCLEROBIOSIS.

The mixed nests of uncertain origin and significance are of considerable interest, but unfortunately they are very rare, and as their origin has never been observed in any single instance either in Europe or America, it is possible to do little more in the present state of our knowledge than to catalogue the different cases. Mixed nests of this character are formed by the union of dominant species with unusual auxiliaries or *vice versa*, or by the close consociation of species which normally inhabit independent colonies. It is generally agreed that such nests must be either predatory unions, established after the manner of dulotic species by robbing the larvæ and pupæ of species which never function as normal auxiliaries, or by alliances between queens of different species before or soon after starting their colonies. Experiment may be expected to throw

considerable light on the extent to which such unions are possible. Forel ('74) and Wasmann ('91) have recorded a number of interesting observations, some of which are very similar to the following cases observed in America.

26. **Formica pergandei** Emery and **F. pallide-fulva** Latr.

Mr. Pergande (Emery, '93[a], p. 646) found near Washington, D. C., a mixed colony of *Formica pergandei* and the typical *F. pallide-fulva*, but the nature of the consociation was not determined. Emery suggests that the former species may be a true dulotic ant and *F. pallide-fulva* its auxiliary species. Mr. Pergande informed him that he had known of the existence of this colony for several years, but had seen only *pallide-fulva* in the nest till the summer of 1892, when the *F. pergandei* made their appearance in the colony. This observation would seem to favor an explanation by alliance rather than dulosis, or, at any rate, on the suppositon of dulosis the rôles of the two species would seem to be the reverse of that suggested by Emery, *pallide-fulva* being the dominant and *pergandei* the auxiliary species.

27. **Formica exsectoides** Forel and **F. subsericea** Say.

Forel ('00[c], p. 12) found a small mixed formicary of these species at Hartford, Conn. "There could be no doubt concerning the intimate life in common of the two species in the same nest. They entered and went out through the same doors, etc." Rev. P. J. Schmitt writes me that he has found at different times five different nests of *F. exsectoides-subsericea*. These invariably contained females of the *exsectoides* only. All these colonies were, moreover, obviously incipient, as shown by the fact that they contained scarcely more than fifty ants, including both species. These six cases observed by Forel and Schmitt are probably of the same nature as the very similar cases of *F. exsecta-fusca*, *F. truncicola-fusca*, *F. exsecta-pressilabris-fusca*, *F. pratensis-fusca*, and *F. sanguinea-rufa-fusca* described by Forel ('74) and Wasmann ('91). It is probable that the American *exsectoides*, like the European

exsecta, has dulotic proclivities which are shown only while the colony is young. In this connection the above-recorded fact, that weak colonies of *F. sanguinea* are found to have the most slaves, is perhaps significant.

28. **Dorymyrmex pyramicus** Roger, vars. **niger** Forel and **flavus** McCook.

A peculiar mixed colony containing both the common varieties of *Dorymyrmex pyramicus* was found by Forel at Faisons N. C. ('00[c], p. 5). "There were two or three nests situated several meters apart. The yellow workers and the black workers entered and went out peaceably side by side, worked together and treated one another with every show of friendship. The two forms were, nevertheless, perfectly distinct, without presenting any transitional varieties. I completely demolished one of the nests and had the good fortune to find the females and males of *niger* and the male of *flavus*, the latter being larger and paler." Forel believes that this nest arose "without doubt by the fortuitous association of two fertile females, one of each variety." He therefore regards it as of the same nature as the peculiar mixed nest of *Tapinoma-Bothriomyrmex* which he described in the "Fourmis de la Suisse" ('74, p. 372).

29. **Pogonomyrmex barbatus** Smith and its var. **molifaciens** Buckley.

At Aguas Calientes, Mexico, Dec. 31, 1900, I happened on a huge gravel cone nest of the agricultural ant (*Pogonomyrmex barbatus*), containing about equal numbers of the typical species (with black head and thorax) and the entirely red var. *molifaciens*. There were no transitional varieties. Both forms were living together on the most amicable terms. As I entertained little hope of finding the queens, since this would, in all probability, have required a very careful excavation of the soil to a depth of from five to eight feet, I had to rest satisfied with digging into the nest a short distance and examining the hosts of belligerent workers that swarmed forth. As this was obviously an old and very flourishing colony, there can be little

doubt that it must have been formed by alliance between two or more queens representing the two distinct color varieties. The whole country about Aguas Calientes is covered with the most flourishing nests of these two forms, often very close to each other, so that it is not at all improbable that an occasional mixed nest should arise in this manner.

30. **Stenamma tennesseense** Mayr and **S. fulvum** Roger, subsp. **aquia** Buckley, var. **piceum** Emery.

Rev. P. J. Schmitt found this singular mixed nest near Beatty, Pa. The queen of the colony belonged to *S. tennesseense*. Rev. Mr. Schmitt was impressed by the fact that the nest was under a stone, whereas *tennesseense* normally occurs only in dead wood at Beatty. This seems to be generally true of the species. In Illinois and Wisconsin I have never taken it except in the old logs in the rather open forests.[1] It is a singular fact that in this and in nearly all the other cases of synclerobiosis the two consociating species or varieties represent a light and a dark colored form. This can scarcely be a mere coincidence, but I am unable to suggest any explanation of this peculiar phenomenon.

I cannot conclude this portion of my paper without expressing my indebtedness to Rev. P. J. Schmitt and to Professor Auguste Forel. These gentlemen have most generously sent me specimens of several of the rare and peculiar Formicidæ which I have figured.

(*To be continued.*)

[1] A somewhat similar mixed nest appears to have been found by Moggridge ('**73**, p. 37, footnote) at Mentone. This colony consisted of nearly equal parts of *Stenamma* [s. gen. *Messor*] *structor*, *barbara*, and the red-headed variety of *barbara*.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XVII. The Rotatoria.

H. S. JENNINGS.

The Rotatoria, or wheel animalcules, consist of minute, chiefly microscopic animals, which are everywhere abundant in fresh water. Along with the Protozoa they constitute by far the largest number of species and individuals among the animals to be found in pools, ponds, rivers, and lakes. A few are found in the ocean, but the rotifers are typically fresh-water organisms.

The most characteristic feature in the organization of the Rotatoria is the ciliated area at (or near) the anterior end of the body, serving as a locomotor organ or to bring food to the mouth. Coupled with the lack of cilia elsewhere on the body, this constitutes a character by which a rotifer may as a rule be recognized at once. This ciliated area is usually known as the corona. It varies excessively in form and structure, and in a few rare aberrant species is lacking.

Male and female differ in form, the males being, as a rule, much smaller than the females, and reduced in structure, — usually lacking the alimentary canal. The males are little known, many species existing in which they have never been observed. Discussions of the structure and classification of the rotifers are therefore based generally on the females alone.

The form of the body is exceedingly varied in the different representatives of the group, — ranging from spherical in Trochosphæra to the excessively attenuated form of *Rotifer neptunius* (Fig. 29) or the spiny, turtle-like form of Polychætus (Fig. 111). As a rule, however, the body is somewhat elongated, and is extended at the posterior end, behind the cloaca, to form a long stalk or a tail-like appendage, called the foot.

This frequently ends in two small points, called the toes. There may or may not be a distinct head, set off from the body by a neck. Dorsal and ventral surfaces are usually (not always) markedly differentiated. In many rotifers (Loricata) the cuticula or outer covering of the body is hardened to form a shell or *lorica;* this may bear elevations, spines, teeth, etc.

The simplest and probably primitive form of the corona is that of a plane disk covered with equal cilia, on the ventral side of the animal at the anterior end, as in Proales. From this the varied forms found have probably been derived, chiefly by the following steps : (1) the outer cilia became longer and stronger, forming a distinct marginal wreath; (2) the cilia within this wreath were partly or entirely lost; (3) a second wreath of cilia was developed (or has remained from the original cilia) within or without the above-mentioned wreath. Thus we obtain the condition, which has often been considered the primitive one, of two concentric wreaths, with the mouth between them. This condition is found only in much specialized forms.

In the alimentary canal can be distinguished a mouth, usually situated excentrically in the coronal disk and leading into a muscular pharynx, or *mastax*, which is furnished with chitinous jaws or *trophi;* a narrow œsophagus; a large stomach furnished with a pair of gastric glands, and an intestine leading to the anus. The latter is lacking in some groups. The jaws or trophi are very various in form and furnish a most important systematic character. Certain types of jaws are distinguished; of these, the more important are the malleate (Fig. 170) and the forcipate (Fig. 171). The other forms (ramate, Fig. 34; incudate, Fig. 54; uncinate, Fig. 10, etc.) may be related to one of these two types.

Points of especial practical importance for distinguishing species are the following : form, structure, and position of the corona; presence or absence, form and position, of the foot; form of the toes; presence, number, and position of the red eye-spots; structure of the jaws or trophi; presence or absence of the intestine and anus; nature of the cuticula, — whether soft and flexible or hardened to form a shell or lorica; presence

or absence of appendages on the body; and mode of life, — whether fixed or free-swimming.

The Rotatoria are a cosmopolitan group, so that the same species may be, and as a matter of fact frequently are, found in America, Europe, India, China, and Australia. Our rotifer fauna is, on the whole, so far as known, almost identical with that of the one other well-known continent, — Europe. From this it results that the only entirely satisfactory key for America or any other country would be one including all the species of the group. Two hundred and forty species have thus far been recorded from America; it is probable that nearly as many more will be found before the list can be considered to approach completeness. Under these circumstances the following key to known American species can be considered to have merely provisional value. Moreover, the species of many of the larger genera can be determined only from full descriptions and detailed figures; the key should in such cases be used in connection with fuller accounts.

The classification of the Rotatoria is in an unsatisfactory condition. The system employed by Hudson and Gosse in their monograph of the Rotifera is used almost exclusively, and is therefore adopted in essentials in the present key. But it is undoubtedly unsatisfactory in many ways, separating widely many closely related species, and bringing together some that are widely divergent in essential structure. A better classification has been outlined by Wesenberg-Lund, but this has not yet been worked out in sufficient detail to make its use practically satisfactory in such a key.

Owing to the large number of species of the Rotatoria and the frequent difficulty of assigning definite distinguishing characteristics even to the genera, it will be necessary for the key to the genera and species to be purely artificial in character. I give first, therefore, a systematic synopsis of the orders, suborders, and families. This synopsis is based on that given by Hudson and Gosse in the monograph of the Rotifera. I have introduced certain divisions not given by Hudson and Gosse, — such as the general division into Monogononta and Digononta; this division is one which is employed

by almost all later authors. Certain families, as the Apsilidæ, Plœsomadæ, Gastropodidæ, and Anapodidæ, are added to those given by Hudson and Gosse; this has become necessary through the progress of investigation since the monograph was written.

Many of the definitions are taken from Hudson and Gosse. The system is based throughout on the structure of the females.

SYNOPSIS OF THE ROTATORIA, WITH CHARACTERS OF THE CLASS, SUBCLASSES, AND ORDERS.

CLASS ROTATORIA OR ROTIFERA (WHEEL ANIMALCULES).

Small microscopic organisms, living chiefly in fresh water, bearing at the anterior end a ciliated area which takes various forms. Body often extended backward to form a stalk or foot. Pharynx with chitinous jaws; cloacal opening, when present, on the dorsal side, at the boundary between body and foot. Excretory organs in the form of fine tubes bearing "flame cells" or "vibratile tags," and opening into a contractile vacuole near the cloaca. Sexes separate; males usually minute, degenerate, lacking the alimentary canal.

SUBCLASS 1, DIGONONTA (HAVING TWO OVARIES).

Order 1. Bdelloida. Swimming with the ciliary wreath and creeping like a leech (or parasitic). Jaws ramate (Fig. 34).

Family 1. Philodinadæ.

Genera. Philodina, Rotifer, Callidina, Discopus.

Family 2. Adinetadæ.

Genus. Adineta.

Order 2. Seisonacea. Marine; parasitic on Nebalia; no corona. Males not degenerate.

Family 3. Seisonidæ.

Genera. Seison, Paraseison, Saccobdella.

SUBCLASS 2, MONOGONONTA (HAVING ONLY ONE OVARY).

Order 4. Rhizota. Fixed forms; foot ending in a disk or cup.

Family 4. Floscullariadæ.

Genera. Floscularia, Stephanoceros.

Family 5. Apsilidæ.

Genera. Apsilus, (Acyclus), (Atrochus).

Family 6. Melicertadæ.

Genera. Melicerta, Octotrocha, Limnias, Limnioides, Cephalosiphon, Œcistes, Pseudœcistes, Lacinularia, Megalotrocha, Conochilus.

Order 5. Ploima. Not fixed; swimming with the ciliary wreath; not creeping like a leech. Jaws never ramate.

Suborder 1. Illoricata. Cuticula flexible, not hardened to form a shell or *lorica*.

Family 7. Microcodontidæ.
Genera. Microcodon, Microcodides.

Family 8. Asplanchnadæ.
Genera. Asplanchna, Asplanchnopus, Ascomorpha, (Hertwigia?).

Family 9. Synchætadæ.
Genera. Synchæta, (Anarthra), (Polyarthra).

Family 10. Triarthradæ.
Genera. Triarthra, Pedetes, Pteroessa, (Polyarthra and Anarthra).

Family 11. Hydatinadæ.
Genera. Hydatina, Rhinops, Notops, Triphylus, Cyrtonia.

Family 12. Notommatadæ.
Genera. Albertia, Taphrocampa, Pleurotrocha, Notommata, Copeus, Proales, Furcularia, Triophthalmus, Eosphora, Diglena, Distemma, Notostemma, Arthroglena, (Drilophaga) (Monommata?).

Suborder 2. Loricata. Cuticula stiffened to form a distinct armor or lorica.

Family 13. Rattulidæ.
Genera. Rattulus, Mastigocerca, Elosa, (Cœlopus?), (Diurella?), (Borthriocerca?).

Family 14. Dinocharidæ.
Genera. Dinocharis, Polychætus, Scaridium, (Stephanops).

Family 15. Salpinadæ.
Genera. Salpina, Diplax, Diaschiza, Diplois.

Family 16. Euchlanidæ.
Genera. Euchlanis, Dapidia.

Family 17. Cathypnadæ.
Genera. Cathypna, Distyla, Monostyla.

Family 18. Coluridæ.
Genera. Colurus, Metopidia, Monura, Mytilia, Cochleare, (Stephanops).

Family 19. Pterodinadæ.
Genera. Pterodina, Pompholyx.

Family 20. Brachionidæ.
Genera. Brachionus, Schizocerca, Noteus.

Family 21. Anuræadæ.
Genera. Anuræa, Notholca, Eretmia.

Family 22. Plœsomadæ.
Genus. Plœsoma.

Family 23. Gastropodidæ.
Genera. Gastropus, Hypopus.

Family 24. Anapodidæ.
Genera. Anapus, (Hertwigia).

Order 6. Scirtopoda. Swimming by means of branched appendages resembling in some respects those of the Crustacea. (The ordinal value of this character is decidedly doubtful.)

Family 25. Pedalionadæ.

Genera. Pedalion, Hexarthra.

Of uncertain sytematic position — Trochosphæra, Atrochus, Adactyla, Balatro, Cypridicola.

ARTIFICIAL KEY FOR THE DETERMINATION OF THE GENUS AND SPECIES OF AMERICAN ROTATORIA.

A1. Adult animals attached or united in colonies, usually dwelling in tubes; or if separate and free-swimming, then carrying the transparent tube with them. Foot ending in a flat disk or cup, which is attached to the substratum or to the bottom of the tube (or foot absent in Nos. 15–17) (free-swimming when young) Order RHIZOTA, H. & G.

B1. Not forming colonies; corona with long slender setæ and usually produced into a varying number of lobes bearing the setæ; mouth in the center of the large corona; cilia few, about the mouth, scarcely noticeable. Trophi uncinate (Fig. 10) . . Family FLOSCULARIADÆ

a1. Setæ not arranged in whorls or parallel rows on the lobes of the corona, but scattered or in groups . . . . . Floscularia

b1. Free-swimming, carrying the transparent tube

c1. Corona two-lobed; two eyes on the dorsal lobe . 1, *Floscularia mutabilis* Bolton

c2. Corona circular, ciliated, with five short prominences bearing setæ . . . . . 2, *F. pelagica* Rousselet (Fig. 1)

b2. Not free-swimming

c1. Corona without distinct lobes, but transversely truncate; setæ short, chiefly on the dorsal and ventral parts of the corona 3, *F. edentata* Collins (Fig. 2)

c2. Lobes of the corona three

d1. Lobes large, separated by deep curved depressions; setæ on the entire rim of the corona . . . . 4, *F. trilobata* Collins (Fig. 3)

d2. Lobes apparently but three — one large dorsal and two small ventral ones; but really with two minute additional lobes between the dorsal and ventral. See *c3*.

c3. Lobes five

d1. A long flexible process on the back of the dorsal lobe; lobes knobbed . . . . . 5, *F. cornuta* Dobie (Fig. 4)

d2. No dorsal process; lobes knobbed

e1. Lobes rather long and slender . . . . 6, *F. coronetta* Cubitt (Fig. 5)

e2 Lobes shorter and thicker . . 7, *F. ornata* Ehr. (Fig. 6)

d3. Lobes broad, not knobbed, all five well marked; setæ arising both from the summit of the lobes and from the intervening depressions . . . . . 8, *F. campanulata* Dobie (Fig. 7)

d4. The two lateral lobes very small, at first view hardly noticeable; dorsal lobe much larger than ventral

e1. Corona ornamented with dots arranged in symmetrical patterns; animal very small; tube sometimes lacking 9, *F. algicola* Hudson (Fig. 8)

e2. Larger, corona not ornamented as in *e1* 10, *F. ambigua* Hudson

d5. The five lobes forming long slender pointed arms, like those of Stephanoceros (Fig. 9) . . . . . 11, *F. millsii* Kellicott

c4. Lobes seven . . . . . 12, *F. regalis* Hudson

a2. Setæ arranged in whorls or oblique parallel rows on the five long pointed lobes of the corona . . . . 13, *Stephanoceros eichhornii* Ehr. (Figs. 9 and 10)

B2. Corona without setæ and apparently without cilia (a minute ciliary wreath can usually be detected on careful search)

a1. Corona with one dorsal lobe, the coronal cup edged with a delicate festooned membrane; body long, with a long slender tapering stalk, by which it is attached. Living in colonies of *Megalotrocha albo-flavicans* . . . . . 14, *Acyclus inquietus* Leidy (Fig. 11)

a2. Coronal cup a large membranous sack; body short and thick; no foot, — the animal being attached by a flat disk . . . . Apsilus

b1. Coronal cup not oblique, its frontal margin horizontal 15, *A. vorax* Leidy

b2. Coronal cup and its frontal margin oblique; ganglion or brain in the neck

c1. Ventral margin of the coronal cup with a central convex lobe-like projection . . . . . 16, *A. bipera* Foulke (Fig. 12)

c2. Ventral margin of cup even, without central projecting lobe 17, *A. bucinedax* Forbes (Fig. 13)

B3. Corona without setæ and not produced into long lobes, but with strong conspicuous moving cilia forming a marginal continuous curve about the corona. In this curve there is a more or less conspicuous gap on the dorsal side. Mouth near the ventral side of the corona. On the body just below the corona either a single dorsal antenna, or two ventral ones, or all three, are noticeable. Trophi malleo-ramate (Fig. 16)

a1. Individuals attached, separate, or in branching non-spherical colonies of few specimens (1–30 or thereabouts)

b1. Corona of four lobes (or in No. 21 of three lobes); ventral antennæ obvious; dorsal antenna minute . . . . . Melicerta

c1. Lobes of the corona when expanded wider than the tube; a short, blunt chin on the ventral side below the corona; tube formed of nearly spherical pellets . . . . . 18, *M. ringens* Schrank (Figs. 14, 15, and 16)

c2. Lobes when expanded of the same width as the tube; chin long and pointed; tube of pellets having the form of a pointed cylinder . . . . . 19, *M. conifera* Hudson (Fig. 17)

c3. Lobes when expanded more than three times the width of the body; ventral antennæ very long; tube gelatinous, without pellets . . . . . 20, *M. tubicolaria* Ehr.

c4. Upper (ventral) pair of lobes separated by a large notch; lower (dorsal) pair almost confluent, so that the corona seems to have but three lobes; ventral antennæ short; chin two-pointed. Tube with ovoid fæcal pellets, or floccose, without pellets 21, *M. janus* Hudson (Fig. 18)

b2. Corona broad, of two lobes, with a wide dorsal gap; dorsal antenna minute; ventral antennæ obvious; tube without pellets Limnias

c1. Tube cylindrical, transparent, ringed by transverse ridges at regular intervals; five horny processes on the dorsal surface of the body, below the corona 22, *L. annulatus* Bailey (Fig. 19)

c2. Tube nearly cylindrical, not ringed, often partly covered with débris; no horny processes on dorsal surface of the body; ventral antennæ very short . . . . . 23, *L. ceratophylli* Schrank

c3. Tube roughened with transverse rows of raised points; seven horny processes on the dorsal surface of the body below the corona; ventral antennæ nearly equal in length to the diameter of the tube . . . . . 24, *L. shiawasseensis* Kellicott

b3. Corona nearly circular, with a distinct dorsal gap; *dorsal antenna very large*, with two projections or hooks at its sides; ventral antennæ small or absent . . . . . Cephalosiphon

c1. Tube tapering to the foot, compact, strengthened with extraneous material; foot very long ar d slender . . 25, *C. limnias* Ehr. (Fig. 20)

c2. Tube irregular, semitransparent, gelatinous 26, *C. candidus* Hudson

b4. Corona a wide oval (or nearly circular), indistinctly two-lobed; dorsal gap minute, ventral antennæ obvious; dorsal antenna inconspicuous or absent . . . . . Œcistes

c1. One or more dorsal hooks or projections below the corona; ventral antennæ minute; tube absent or small and irregular

d1. Two dorsal hooks below the corona; these sometimes branched into antler-like structures . . . 27, *O. melicerta* Ehr. (Fig. 21)

d2. A single dorsal hook below the corona; foot very long; animal without a tube, living in the mucilaginous matrix of the alga *Gloiotricha pisum* . . . . . 28, *O. mucicola* Kell.

c2. Antennæ (ventral) very short; no dorsal hooks

d1. Antennæ set wide apart; tube very irregular and variable, often beset with extraneous matter . . . 29, *O. crystallinus* Ehr. (Fig. 22)

d2. Dorsal gap of the corona very wide; tube opaque, regular, tapering slightly from top to bottom . . 30, *O. intermedius* Davis (Fig. 23)

c3. Antennæ long

d1. Antennæ very long and recurved, tube floccose; very small 31, *O. longicornis* Davis

d2. Corona large, nearly circular, crossed with thick ribs, tube loose, very irregular, clay colored . 32, *O. umbella* Hudson

a2. Not attached; inhabiting a tube; individuals separate or one adult grouped with its young

b1. Corona horseshoe-shaped; two antennæ on the ventral surface of the body, united almost to their tips 33, *Conochilus dossuarius* Hudson

a3. In clusters of many individuals, forming usually a spherical colony, appearing to the naked eye as a small yellowish or grayish ball

b1. Clusters attached

c1. Body (in known American species) with two or four opaque warts in a transverse row on the ventral side. No tube. Corona broad, kidney-shaped, with short axis dorso-ventral; antennæ inconspicuous . . . . . Megalotrocha

d1. Opaque warts two . . . . . 34, *M. semibullata* Hudson (Fig. 24)

d2. Opaque warts four . . . . . 35, *M. alboflavicans* Ehr. (Fig. 25)

c2. Dwelling in transparent gelatinous tubes; body without opaque warts or denticles; corona heart-shaped with long axis dorso-ventral; antennæ inconspicuous. 36, *Lacinularia socialis* Ehr.

b2. Free-swimming colonies or clusters . . . . . Conochilus

c1. Antennæ two, separate except at the base, situated on the corona, between the mouth and the ventral gap; colonies spherical, of many individuals . . . . 37, *C. volvox* Ehr. (Fig. 26)

c2. Antennæ united, so as to appear single, large and conspicuous, and situated on the corona; clusters usually unsymmetrical and containing comparatively few individuals . . 38, *C. unicornis* Rousselet (Fig. 27)

(*C. dossuarius* — see No. 33)

A2. Not fixed when adult; not forming colonies nor living in tubes (in a few rare cases the animal lives in a tube, but is never attached by its foot to the bottom of the tube, as in *A1*)

B1. Without *lorica*; *i.e.*, the cuticle of the animal is flexible, not stiffened to form an unyielding armor or *lorica*

a1. Swimming with the corona and creeping like a leech; body usually nearly cylindrical (dorsal and ventral surfaces not being conspicuously differentiated), and composed of rings which may be drawn one within the other in a telescopic fashion. Foot (reckoned from the cloaca to

the tip) usually ending in three toes, and bearing two to four spurs some distance from the tip. A dorsal proboscis behind the corona. Trophi or jaws ramate (Fig. 34). (Ovaries two.) Order BDELLOIDA

b1. Corona of two nearly circular retractile lobes, transversely placed Family PHILODINIDÆ

c1. Eyes two

d1. Eyes on the frontal column or proboscis . . . . Rotifer

e1. Constructing and dwelling in tubes 39, *R. mento* Anderson

e2. Not living in tubes

f1. Antenna very long (one-half to one-third as long as the body); foot short (one-third body length); spurs short and thick . . . . . 40, *R. macroceros* Gosse (Fig. 28)

f2. Antenna not remarkably long

g1. Body very long and slender, white and transparent; foot extraordinarily long (one and one-half times the length of the rest of the body); toes long and slender 41, *R. neptunius* Ehr. (Fig. 29)

g2. Foot not remarkably long

h1. Spurs not twice as long as the width of the joint to which they are attached. Body transparent or whitish, not colored or dark.

i1. Body whitish, opaque, passing gradually into the foot; spurs one and one-half times as long as the width of the joint to which they are attached, and forming an obtuse angle with each other 42, *R. vulgaris* Schrank (Fig. 30)

i2. Body thick, suddenly decreasing in size to form the foot, which makes up half the entire length of the animal; spurs produced to a longish point at the tip 43, *R. macrurus* Schrank

h2. Spurs at least twice as long as the width of the joint to which they are attached.

i1. Foot short, distinctly marked off; toes long, three-jointed; spurs thrice as long as the width of the joint to which they are attached, and with a constriction one-third of their length from the tip 44, *R. trisecatus* Weber (Fig. 31)

i2. Body slender; foot long, not distinctly marked off from the body; spurs twice as long as the width of the joint to which they are attached, slightly swollen at base 45, *R. elongatus* Weber (Fig. 32)

i3. Body colored — dark brown, usually covered with débris; transverse folds very marked; spurs almost, or quite, three times as long as the width of the joint to which they are attached 46, *R. tardus* Ehr. (Fig. 33)

d2. Eyes in the "neck" — directly over the brain, just above the jaws . . . . . Philodina

e1. Three teeth in each jaw (Fig. 34)

f1. Body beset with strong spines on the dorsal surface 47, *P. aculeata* Ehr. (Fig. 34)

f2. Body without spines, surface usually sticky, so that it is frequently covered with débris; spurs long and sharp, two and one-half times as long as the width of the joint to which they are attached . . . 48, *P. macrostyla* Ehr.

e2. Two teeth in each jaw

f1. Body smooth, colorless, very short, thickened in the middle; corona very large; foot sharply set off from the body; spurs shorter than the width of the joint to which they are attached . . . 49, *P. megalotrocha* (Fig. 35)

f2. Body colorless or reddish, not short and thick; foot not distinctly marked off . . . . . 50, *P. roseola* Ehr.

f3. Body greenish yellow, otherwise much like the last 51, *P. citrina* Ehr.

d3. Eyes none . . . . . Callidina

(The genus Callidina is a very large and difficult one; while the following species are all that have been identified in America, doubtless many more will be found.)

e1. Living in a tube . . . 52, *C. eremita* Bryce (Fig. 36)

e2. Not living in a tube

f1. Body with stout, blunt dorsal papillæ, especially on the segment next to the foot 53, *C. papillosa* Thompson (Fig. 37)

f2. Body without papillæ or spines

g1. Foot ending in toes

h1. Jaws (Fig. 38) small, with numerous (8–10) fine ridges ("teeth")

i1. Corona as wide as the neck; ridges ("teeth"), ten in each jaw (Fig. 38); spurs drawn to a slender point . . . . . 54, *C. elegans* Ehr. (Fig. 38)

i2. Corona not so wide as the neck; ridges or teeth, eight in each jaw (Fig. 39); spurs (Fig. 40) short and broad 55, *C. constricta* Dujardin (Figs. 39 and 40)

h2. Jaws with but two distinct teeth (in addition to a number of fine ridges)

i1. Teeth two in each jaw; spurs at least twice as long as the width of the joint to which they are attached, straight and thick; body colorless. Parasitic on Asellus 56, *C. socialis* Kellicott (Fig. 41)

i2. Each jaw (Fig. 42) with one large and two small teeth; spurs (Fig. 43) scarcely as long as the width of the joint to which they are attached, swollen at base; body yellowish
57, *C. musculosa* Milne (Figs. 42 and 43)

g2. Foot ending in a disk in place of toes; teeth, six to eight in each jaw; body reddish . 58, *C. magna* Plate

b2. Corona a flat surface covered with cilia, on the ventral side of the anterior end (Fig. 44) . . . . . Adineta

c1. Skin smooth; no eyes; proboscis without bristles and with a few cilia; body broad . . . . 59, *A. vaga* Davis (Fig. 44)

a2. Swimming with the corona; not creeping like a leech (sometimes creeping with the toes). Jaws of various forms, but never ramate.

A very large number of rotifers fall within this division, and the recognition of species, or in many cases even of genera, is very difficult. In order to reduce the difficulties to a minimum, I separate out a number of species having striking peculiarities, by means of the first five subdivisions given below (*b1–b5*). The following is to be especially noted; *only the species mentioned under a given characteristic possess that characteristic.* For example, any species having swimming appendages will be found under *b5;* species not named under this subdivision do not have such appendages.

b1. Spherical in form; no foot; ciliary wreath midway between the equator and one pole of the sphere
60, *Trochosphæra solstitialis* Thorpe

b2. Foot ending in a *single* pointed "toe"

c1. Corona a circle of strong cilia; mouth in the center; form of the body conical; one eye 61, *Microcodon clavus* Ehr. (Fig. 45)

c2. Corona an oblique ciliated disk, with two auricles; body brownish red or cherry red in color; one eye
62, *Notommata monopus* Jennings (Fig. 46)

c3. Corona an oblique ciliated surface with weak cilia; no eye; parasitic in fresh-water annelids . 63, *Albertia naidis* Bousfield

b3. Foot ending in two pointed projections, not side by side (as in most rotifers), but one dorsal, the other ventral. Otherwise much like No. 61
64, *Microcodides chlæna* Gosse (*orbiculodiscus* Thorpe)

b4. Corona extended dorsally into a large and broad proboscis, fringed with cilia and bearing near its end two red eyes
65, *Rhinops vitrea* Hudson (Fig. 47)

b5. Body bearing swimming or skipping appendages, in the form of movable spines, blades, or branching crustacean-like limbs; no foot

c1. Six branching appendages, somewhat like those of a crustacean; two small stylate appendages on the posterior dorsal surface. Eyes two . . 66, *Pedalion mirum* Hudson (Fig. 48)

c2. Twelve blade-shaped appendages, with serrate edges, arranged

in four groups of three each, at about the level of the jaws. One eye . . . . . 67, *Polyarthra platyptera* Ehr. (Fig. 49)

c3. Two very long spines (thrice the length of the body), attached ventro-laterally ; eyes two . . . . 68, *Pedetes saltator* Gosse

c4. Three very long spines, two lateral, one ventral. Two eyes 69, *Triarthra longiseta* Ehr. (Fig. 50)

(The remainder of the group (*a2*) are less easily recognizable. It will facilitate the use of the rest of the key to this subdivision to point out in a preliminary way certain striking characteristics of a number of species.)

No eyes. — *Hydatina senta* (No. 87), Albertia (No. 63), Pleurotrocha (No. 91), *Taphrocampa saundersiæ* (?) (No. 92), *Diglena contorta* (No. 93).

Eyes two. — Rhinops (No. 65), Diglena (Nos. 124–129), Distemma (No. 130), *Taphrocampa saundersiæ* (?) (No. 92), Triphylus (No. 85), Pedalion (No. 66), Pedetes (No. 68), Triarthra (No. 69).

Eyes three. — *Asplanchna priodonta* (No. 74), *Asplanchna herrickii* (No. 73), *Triophthalmus dorsualis* (No. 122), Eosphora (No. 123).

Parasitic. — External, — *Pleurotrocha parasitica* (No. 91). Internal, — Albertia (No. 63), Hertwigia (No. 80), *Proales wernecki* (No. 110).

Viviparous (the developing embryo frequently seen within the mother). — Asplanchnopus (No. 70), Asplanchna (Nos. 71–76), *Rhinops vitrea* (No. 65).

No foot. — Trochosphæra (No. 60), Pedalion (No. 66), Polyarthra (No. 67), Pedetes (No. 68), Triarthra (No. 69), Asplanchna (Nos. 71–76), Ascomorpha (Nos. 77–79), Hertwigia (No. 80), Anarthra (No. 81).

b6. No anus, the intestine ending blindly

c1. Foot present (viviparous) . . . . . Asplanchnopus

d1. Foot small, on the ventral surface 70, *A. myrmeleo* Ehr. (Fig. 51)

c2. No foot

d1. Large, clear, sac-like animals, with incudate jaws (Fig. 54); corona with two slight conical elevations. Viviparous Asplanchna

e1. Sac-like body with large projections or "humps"

f1. Four humps, — one dorsal, one ventral, and two lateral 71, *A. ebbesbornii* Hudson (Fig. 52)

f2. Three humps, — like the last but with the ventral one lacking (perhaps a variation of 71) . 72, *A. amphora* Hudson

e2. Sac-like body without humps

f1. Eyes three, — one large, on the brain, two small, lateral

g1. A bilobed glandular organ (Fig. 53, *a*) attached close to the opening of the ovary and excretory organs; 20–25 flame cells on each excretory tube
73, *A. herrickii* de Guerne (Fig. 53)

g2. No glandular organ as described in 73; flame cells but 3–5 on each excretory tube 74, *A. priodonta* Gosse

f2. Only one eye

g1. Jaws stout, with doubly pointed ends not serrated (Fig. 54); flame cells 10–20 on each side
75, *A. brightwellii* Gosse

g2. Jaws weaker, ending in a blunt tooth and a broad, thin plate (Fig. 55) (probably a variety of the last)
76, *A. girodi* de Guerne

d2. Very small rotifers, sac-like; corona rising slightly to a single apex; jaws not incudate; not viviparous
Ascomorpha

e1. A single large projecting process at the mid-dorsal edge of the corona

f1. Ovate in form; hyaline except the stomach; on each side of the body a "sub-dorsal groove". 77, *A. hyalina* Kellicott (Fig. 56)

f2. Flattened; in one view nearly circular, with a neck-like projection; in the edge view oblong, half as long as wide; skin stiffened so as almost to form a lorica
78, *A. orbicularis* Kellicott (?)

(This species is probably founded on dead specimens of *Gastropus stylifer*, No. 153.)

e2. No large projecting process on the corona; dorsal view sac-like; lateral view unsymmetrical, with a gibbous dorsal outline; color usually dark green . . . . 79, *A. ecaudis* Perty (*A. helvetica* Perty; *Sacculus viridis* Gosse) (Fig. 57)

b7. Foot not present; no appendages to body; anus present

c1. Parasitic in Volvox; having a large mid-dorsal projecting process on the corona . . . . 80, *Hertwigia parasita* Ehr.

c2. Not parasitic; body an elongated, parallel-sided, flattened sac; corona squarely transverse, with a single marginal wreath of cilia, and with two broad, flat setæ-bearing prominences on the dorsal side and two long styles near the ventral side . 81, *Anarthra aptera* Hood (Fig. 58)
(See also Trochosphæra, No. 60)

b8. Foot present, ending in two toes placed side by side; body without swimming appendages; anus present

c1. Form a broad, often swollen, cone, of which the foot forms the apex. Corona large, transverse, flat or strongly convex, with four

long styles and a number of styligerous prominences; at the sides of the corona two large ciliated auricles, which may be retracted. A single eye . . . . . Synchæta

d1. The slender foot one-third to one-half the length of the remainder of the body; toes minute . . . . 82, *S. stylata* Wierzejski (Fig. 59)

d2. Foot very short (less than one-sixth the length of the rest of the body)

e1. Body a swollen cone; corona strongly convex, with two central thick, club-shaped prominences; auricles very long, usually inclined backward . . . . 83, *S. pectinata* Ehr.

e2. Body a slender cone; coronal surface almost flat, without club-shaped prominences; auricles small . 84, *S. tremula* Ehr. (Fig. 60)

c2. Corona large, nearly transverse (slightly oblique), surrounded by a wreath of cilia which is interrupted ventrally, and bearing a number (3–7) of large prominences crowned with styles; mouth near the ventral side of the corona

d1. Eyes two; jaws forcipate; foot slender, of three joints; stomach with six long cæcal projections . . . 85, *Triphylus lacustris* Ehr. (Fig. 61)

d2. Eyes one or none

e1. Eye one; body long conical, humped dorsally, its outline with three distinct curves; corona with three styligerous prominences. Ciliary wreath encircling the corona and a sub-square space at right angles to the corona on the ventral surface . . . . . 86, *Cyrtonia tuba* Ehr. (Fig. 62)

e2. No eye; body long conical; a large rotifer, 87, *Hydatina senta* Ehr. (Fig. 63)

e3. Body large, sac-shaped, hyaline (like an Asplanchna), foot very small and retractile, situated at the posterior ventral angle of the body, almost on the ventral surface. Jaws malleate; eye single . . 88, *Notops clavulatus* Ehr. (Fig. 64)

e4. Body strongly arched dorsally; nearly flat ventrally; cuticula thickened into a number of definite but inconspicuous folds or teeth (so that the animal might almost be considered loricate); foot continuing the body axis, but nearer the ventral side, with two small retractile toes; one eye 89, *Notops pelagicus* Jennings (Fig. 65)

e5. Body almost square in ventral view; foot one-third of total length, forming a continuation of the body axis; one eye . . . . . 90, *Notops brachionus* Ehr.

c3. Corona without prominences bearing styles; consisting of an oblique (or even ventral) disk or area covered with close-set cilia or with numerous interrupted ciliary curves. Two lateral evertible

ciliated projections (auricles) present in many species. Jaws forcipate. Soft, flexible, elongated rotifers; exceedingly numerous (Family NOTOMMATADÆ)

d1. Without eyes . . . . . Pleurotrocha

e1. Externally parasitic on fresh-water annelids 91, *P. parasitica* Jennings

e2. Free-swimming, body elongated, fusiform, with numerous marked annulations; head enlarged, with a decurved hood or fleshy proboscis in front; possibly one or two eyes present 92, *Taphrocampa saundersiæ* Gosse (Fig. 66)

e3. Free-swimming; elongated, convex above and gibbous posteriorly, flat ventrally; indications of a neck between head and body; a small hook-like proboscis in front; corona a ventral ciliated area one-third the length of the body; foot very small; toes minute; auricles present; two dorsal antennæ; brain with dark granules at the posterior end 93, *P.* (Diglena) *contorta* Stokes

d2. One eye

e1. Eye in the neck, — that is, attached to the brain, some distance from the front of the head

f1. Body with numerous permanent conspicuous annulations or crenulations; minute larva-like forms; a small projection or "tail" just dorsad of the toes; protrusible auricles present but frequently remaining hidden Taphrocampa

g1. Body nearly cylindrical, short, thick; brain opaque; two auricles present

h1. Toes short and thick, conical, diverging so as to make an acute angle . . . . . 94, *T. annulosa* Gosse (Fig. 67)

h2. Toes longer, slender and curved; so placed that the two together form the outline of a crescent 95, *T. selenura* Gosse (Fig. 68)

g2. Body elongated fusiform, crenulate; head not enlarged; brain containing a club-shaped granular region; toes short; stout, conical, forming an acute angle with each other . . . 96, *T. clavigera* Stokes (See also No. 92, *T. saundersiæ*)

f2. Body without numerous permanent conspicuous annulations (though divisible into a number of joints) (Cuticula somewhat stiffened and with a slight longitudinal dorsal cleft, — see Diaschiza, Nos. 181, 182)

g1. Very large species (.2 to .7 mm. in length), slow moving, usually enlarged behind the middle; brain three (or five) lobed, clear or opaque; corona extending onto

the ventral surface as a large movable ciliated "lip" (except in Nos. 99, 100, and 101); body projecting backward over the foot as a jointed or sac-like tail; auricles usually present . . . . . Copeus

h1. The two toes alike

i1. Tail slender, usually pointed, prominent, obscurely two-jointed; foot two-jointed

j1. Auricles very long (longer than the width of the head), extending laterally, ciliated only at the tip and along the anterior side . 97, *C. copeus* Ehr. (or *C. ehrenbergii* Gosse) (Fig. 69)

j2. Auricles very small or absent 98, *C. labiatus* Gosse

(97 and 98 are probably identical, 98 being founded on specimens of 97, with the auricles retracted)

i2. Tail thick, rounded, bag-like; auricles large, broadest at base

j1. Brain three-lobed . . . 99, *C. pachyurus* Gosse (Fig. 70)

j2. Brain five-lobed . . 100, *C. quinquelobatus* Stokes

(Probably a variation of 99)

i3. Tail small, inconspicuous; brain three-lobed

j1. Tail a minute tubercle; corona without lip; auricles very small; toes very small 101, *C. cerberus* Gosse (Fig. 71)

h2. The two toes dissimilar in form; tail slender, rounded; no lip 102, *C. americanus* Pell (Fig. 72)

g2. Moderate-sized or small (except No. 106); auricles present; toes small; brain usually partly opaque, not three-lobed; body often projecting behind, above the foot, as a large or small "tail" . . . . Notommata

(A difficult genus with very numerous species, — many of the American ones not yet identified)

h1. Tail long, almost or quite as long as the toes, so that the animal seems to end caudally in three prominent toes . . . 103, *N. tripus* Ehr. (Fig. 73)

h2. Tail inconspicuous or absent

i1. Brain clear; body fusiform; head narrower than the body; auricles small; toes minute cones; foot very short . 104, *N. brachyota* Ehr. (Fig. 74)

i2. Brain more or less opaque

j1. Color orange red or brick red, with a brownish tinge; body long, cylindrical, truncate at each end; cilia extending onto ventral surface almost

one-fourth the length of the body; toes very small; a separate foot scarcely distinguishable. Eye near the caudal end of the brain, almost completely hidden by the dense opacity of the latter . . 105, *N. truncata* Jennings (Fig. 75)

j2. Body subcylindrical or sac-like, swollen behind

k1. Very large and slow; body sac-like, with a swollen neck, between which and the body is a constriction; foot short; toes minute 106, *N. collaris* Ehr. (Fig. 76)

k2. Smaller; body subcylindrical; head wide; brain with a spherical opaque mass behind, bearing the eye, and connected by a tube with the front; foot very short, of two joints; toes small, long conical in form. Length, .2 to .3 mm . . . 107, *N. aurita* Ehr. (Fig. 77)

k3. Like *N. aurita*, but smaller and more slender; toes much longer and decurved; the eye sometimes hidden by the opaque brain. Length about .15 mm. . . 108, *N. cyrtopus* Gosse (Fig. 78)

j3. Body cylindrical, long, flexible, with a number of transverse constrictions and longitudinal folds, slightly tapering toward each end; auricles two stalked spheres, with the cilia confined to the spheres; toes very small; brain long, cylindrical, opaque at the caudal end; eye just in front of the opacity . . 109, *N. torulosa* Duj. (Fig. 79)
(*N. vorax* Stokes would be characterized in the same manner; it is probably a synonym of *N. torulosa*.)
(See also No: 62, *N. monopus* Jennings)

g3. No auricles, corona a ciliated surface, oblique or extending onto the ventral surface; brain clear; body cylindrical or larviform, usually small Proales

(A large, ill-defined genus, many of its American representatives unidentified or undescribed. The following American species have been reported)

h1. With a small decurved fleshy proboscis at the front

i1. Parasitic in Vaucheria, forming galls; body fusiform; toes small, straight, pointed 110, *P. werneckii* Ehr.

i2. Free-swimming; body cylindrical, slender, fluted longitudinally; proboscis large; eye very large; foot stout; toes slender; pointed . . . 111, *P. felis* Ehr. (Fig. 80)

h2. No proboscis

i1. Living in gelatinous masses of algæ, or sometimes free in waters full of unicellular algæ. Body nearly cylindrical or oval, slightly arched dorsally; eye large, in two parts, at the anterior border of the brain; foot and toes minute. Adults yellowish brown in color . . . 112, *P. algicola* Kellicott

i2. Body nearly cylindrical, thick, clumsy; head broad, truncate; foot very broad, with a depression in the median line; toes conical
113, *P. sordida* Gosse (Fig. 81)

i3. Body thick, broadest at the head, very flexible and changeable, colorless; toes minute, conical; eye small, inconspicuous . . 114, *P.* (Furcularia) *micropus* Gosse (Fig. 82)

i4. Body slender, soft, larva-like; toes minute; foot indistinguishable . . . . . 115, *P. decipiens* Ehr. (Fig. 83)

i5. Body strongly arched dorsally, flat or convex ventrally; foot conical; toes minute
116, *P. gibba* Ehr. (Fig. 84)

(The animal described under this name by Hudson and Gosse is totally different from Ehrenberg's)

e2. Eye frontal, placed near or at the anterior end of the body. Body nearly cylindrical, somewhat larviform, frequently enlarged in the lumbar region; anterior end conical; corona oblique; the two toes usually rather large and conspicuous
Furcularia

f1. Toes unequal, very long and slender
117, *F. longiseta* Ehr.

f2. Toes equal

g1. Toes blade-shaped, acute, decurved, the ventral edge of each notched with two (or sometimes three or more) teeth . . . . . 118, *F. forficula* Ehr. (Fig. 85)

g2. Toes round and stout at base, and abruptly passing at about a third of their length from the base into a hair-like filament . . . . . 119, *F. semisetifera* Glascott

g3. Body slender, compressed, the ventral line making a prominent angle; front rounded; face oblique; toes slender, straight, acute . . . . . 120, *F. gracilis* Ehr. (Fig. 86)

g4. Body oblong, slightly compressed, convex on the back, abruptly falling off steeply to the foot; toes stylate, straight, acute, nearly half the length of the body
121, *F. gibba* Ehr. (*Diaschiza semiaperta* Gosse?) (Fig. 87) (*F. micropus*, — see No. 114)

d3. Three eyes

e1. Eyes in a transverse row near the posterior end of the brain . . . 122, *Triophthalmus dorsualis* Ehr. (Fig. 88)

e2. One large eye on the brain ("cervical"); two smaller ones on the front . . . . . Eosphora

f1. Body sac-like, swollen behind, convex dorsally; head separated from the body by a neck, and bearing two prominent auricles; foot slender; toes short, acute 123, *E. aurita* Ehr. (Fig. 89)

d4. Eyes two

e1. Eyes frontal; body usually swelling behind and tapering toward the head; toes usually large; jaws prominent, forcipate . . . . . Diglena

f1. A decurved fleshy lobe or hook-like proboscis hanging onto the face from the dorsal margin of the anterior end

g1. Body massive, subcylindrical, dorsum convex, swollen behind; corona a ventral ciliated area; foot a single large joint; toes parallel-sided, abruptly pointed 124, *D. grandis* Gosse (Fig. 90)

g2. Body cylindrical, stout, obtuse at each end, not swollen behind; corona a long ventral area; toes long, curved, somewhat enlarged at base 125, *D. forcipata* Ehr. (Fig. 91)

g3. Eyes colorless; body slender at each end, swollen in the middle; proboscis acute; toes long, slender, curved strongly inward and downward . . 126, *D. circinator* Gosse (Fig. 92)

f2. No proboscis

g1. Body cylindric, long, slender; front broadly truncate (obliquely); foot short, thick: toes long, straight, slender 127, *D. caudata* Ehr. (Fig. 93)

g2. Body short, cylindric, abruptly truncate at each end; toes short, straight, acute, projected from the ventral side, nearly at right angles to the body axis 128, *D. catellina* Ehr. (Fig. 94)

g3. Body oblong, swollen posteriorly; head larger than neck; toes long, slender, straight, perfectly even in thickness, pointed; eyes very close together; jaws protrusile; alimentary canal large, always filled with green matter . . . . . 129, *D. biraphis* Gosse (Fig. 95)

e2. The two eyes cervical in position . . . . Distemma

f1. Body a slender cone; toes stout, recurved, toothed at base . . . . . 130, *D. forficula* Ehr.

B2. Cuticula stiffened to form an armor or lorica Suborder LORICATA

a1. Foot absent

b1. Lorica oval, compressed, without teeth or spines, formed of two subequal convex plates ; one eye

131, *Anapus ovalis* Bergendal (Fig. 96)

b2. Lorica truncate in front and behind, formed of a convex dorsal and a concave ventral plate ; no teeth nor spines

132, *Anuræa hypelasma* Gosse (Fig. 97)

b3. Lorica with six teeth or spines at the anterior edge (usually box-like in form, open at the anterior and posterior ends ; frequently with spines at the posterior end also)

c1. Lorica oblong, convex above, flattened beneath ; dorsal surface marked off into polygonal areas

d1. Lorica subconical in dorsal view, prolonged at the posterior end into a long, strong spine which is slightly narrowed at its base ; polygonal areas of the dorsal surface divided into right and left sets by a median longitudinal line

133, *Anuræa cochlearis* Gosse (Fig. 98)

d2. Lorica as in *d1*, but posterior spine lacking

Anuræa cochlearis, var. *tecta*

d3. Like *d1*, but there is a median dorsal row of polygonal areas on the lorica . . . . . *Anuræa cochlearis*, var. *stipitata*

d4. Lorica subquadrangular, with a spine at each of the two posterior lateral angles 134, *Anuræa aculeata* Ehr. (Fig. 99)

e1. As in *d4*, but the ridges separating the polygonal areas strongly serrate . . . *Anuræa aculeata*, var. *serrulata*

e2. As in *d4*, but the two posterior spines unequal

Anuræa aculeata, var. *valga*

c2. Dorsal surface of the lorica marked with longitudinal furrows or striations . . . . . Notholca

d1. Lorica a long, narrow, triangular pyramid, prolonged at the posterior end into a long spine, equal in length to the body. Anterior spines large, the right one of the two median spines immensely developed, so as to be as long as the body

135, *N. longispina* Kellicott (Fig. 100)

d2. Ovoid, truncated in front, the anterior spines rather short ; body rounded and without spines posteriorly ; longitudinal striations of dorsal plate strongly marked ; dorsal plate of lorica much wider than the ventral plate 136, *N. striata* Ehr.

d3. Much like *N. striata*, but with a subquadrangular projection from the posterior orifice . . . . . *N. striata*, var. *labis*

d4. Cylindro-conical in form ; dorsal plate extended posteriorly to form a tooth or spine ; ventral plate elevated posteriorly to form a high angular projection . . . 137, *N. foliacea* Ehr.

a2. Foot present

b1. Foot transversely wrinkled or ringed (as in Figs. 101–102) ; very retractile

c1. Foot ending in a ciliated cup; lorica dorso-ventrally flattened, thin; corona transverse, ciliary wreath two lateral semicircles; eyes two . . . . . Pterodina

d1. Lorica very flat, circular, edges thin and without teeth or projections . . . . . 138, *P. patina* Ehr. (Fig. 101) (*P. valvata* is the young of 138)

d2. Lorica oval in dorsal view, concave on the dorsal side; edges of the lorica very thick; no teeth or other projections 139, *P. reflexa* Gosse (Fig. 102)

d3. Lorica thin, broadly ovoid or nearly circular, with a prominent tooth on each side at the posterior lateral margin 140, *P. bidentata* Ternetz

c2. Foot ending in two toes (usually small). Lorica arched dorsally, flat or slightly convex ventrally. Spines or teeth usually (not always) present at the anterior dorsal margin of the lorica (frequently elsewhere also) . . . . . Brachionus

d1. Lorica with *six* teeth or spines at the anterior margin of the dorsal plate (with or without posterior spines)

e1. The two middle anterior spines longest and curving outward; ventro-posterior part of lorica slightly prolonged to form a sort of sheath for the foot; on the dorsal side of this sheath a subsquare piece cut out, so that in dorsal view the foot orifice appears to be bounded by two or three teeth. Two posterior lateral spines long, short, or absent. (Excessively variable) . . 141, *B. bakeri* Ehr. (Fig. 103)

f1. Posterior spines short *B. bakeri*, var. *brevispinus* Ehr.

f2. Sheath for foot unsymmetrical (right side less developed); body covered with tubercles *B. bakeri*, var. *tuberculus* Turner

e2. Two middle anterior spines longest and curving outward; a square plate projecting from the middle of the posterior edge over the foot orifice. Usually two posterior lateral spines on the lorica, these disappearing with age 142, *B. variabilis* Hempel

e3. Anterior spines straight; a deep sinus between the two median ones. No posterior spines 143, *B. urceolaris* Ehr. (*f1.* Reddish, spines broader *B. rubens*, a variation of *B. urceolaris*)

d2. Lorica with but *four* teeth or spines at the anterior dorsal margin

e1. Median anterior spines very short; lateral ones very long. Toes large, each ending in two minute points, so that the foot at first view appears to be bifurcated

f1. Two posterior lateral spines on the lorica, the left one very small, the right one long 144, *B.* (or Schizocerca) *diversicornis* Daday

f2. The two posterior lateral spines equal
B. (or Schizocerca) *diversicornis*, var. *homoceros* Wierz

e2. Four variable (often subequal) anterior spines or teeth. Anterior ventral margin of lorica sinuous. Posterior part of the lorica rounded, either without teeth or with two or four teeth or spines. (Excessively variable) . 145, *B. pala* Ehr.

f1. Median anterior spines very long; no posterior spines
B. pala, var. *dorcas* Gosse

f2. Median anterior spines very long; two marked posterior spines . . . . . *B. pala*, var. *spinosus* Wierz.

e3. Four anterior spines of about equal length. Lorica subquadrate in dorsal view; thick, so that a transverse section would be nearly a circle. A slight invagination in the sides of the lorica in the lumbar region, causing blunt angles on the sides of the lorica. Entire surface covered with minute spinules. No posterior spines
146, *B. punctatus* Hempel (Fig. 104)

d3. Anterior margin of lorica without teeth or spines; at most merely sinuate

e1. Anterior dorsal margin sinuate, with a slight rounded notch in the middle. Lorica usually with irregular bluntly angled outlines and with faceted surface. Posterior extremity with two short blunt processes close to the foot
147, *B. angularis* Gosse

f1. The two posterior processes developed into spines
B. angularis, var. *bidens* Plate

e2. Anterior dorsal margin straight and truncated, with a small median sinus for the dorsal antenna; lorica thin, smooth, flexible. Dorsal surface highly arched; ventral, nearly flat. Toes pointed, and having the inner edges convex, the outer concave . . . 148, *B. mollis* Hempel (Fig. 105)

c3. Foot ending in two toes, and situated on the ventral side of the body; lorica an irregularly oblong or ellipsoidal box, marked with grooves and sometimes with vesicles, closed behind, opened ventrally for the protrusion of the foot . . . . . Plœsoma

d1. Lorica firm, with two wide grooves between three ridges passing transversely across the middle of the dorsal surface; a number of deep longitudinal grooves passing forward and backward from the ends of the transverse grooves; surface covered with fine areolations. Lorica in dorsal view about twice as long as wide, projecting at the anterior dorsal margin in a sharp median point, flanked by two small points or angles
149, *P. lenticulare* Herrick (Fig. 106)

d2. Body short, little longer than wide; lorica with grooves and ridges much as in the last, but more thin and flexible, and not

covered with areolations. Anterior dorsal margin of the lorica truncate, without points 150, *P. truncatum* Levander (Fig. 107)

d3. Lorica soft, covered with coarse areolations, partly arranged in very irregular rows; hinder part of the body retractile and extensile; when extended the body ends posteriorly in a blunt point . . . . . 151, *P. molle* Kellicott

d4. Lorica soft, covered with coarse irregular cuticular vesicles; body thick, short, rounded behind 152, *P. hudsoni* Imhof (Fig. 108)

c4. Foot projecting from the ventral surface, small, lightly ringed, and ending in a single pointed toe. Lorica compressed laterally, so as to be nearly circular in side view, with a sort of projecting collar for the protrusion of the head; in dorsal or ventral view oblong. Lorica rose color; internal organs blue, green, and orange . 153, *Gastropus stylifer* Imhof (Fig. 109)

c5. Foot very small and ending in two small toes; lorica thin, compressed laterally, flask-shaped, with the foot projecting from the ventral surface; size about .10 mm. 154, *Gastropus minor* Rousselet (See also No. 223, *Cochleare turbo*)

b2. Foot present, not transversely wrinkled nor ringed (though often jointed)

c1. Foot distinctly jointed and ending in two small toes; lorica with an arched dorsal plate and a nearly flat ventral one; dorsal surface tuberculate or faceted but not bearing spines. Spines present at the anterior and posterior margins of the lorica

d1. Lorica with ten spines in front and four behind, its whole form markedly unsymmetrical; surface faceted and covered with raised points . . . . 155, *Brachionus militaris* Ehr.

d2. Lorica flattened, only slightly arched dorsally; dorsal surface faceted and roughened; two spines in front, turned ventrally at their tips; two posterior lateral spines. *No eye* 156, *Noteus quadricornis* Ehr. (Fig. 110)

c2. Lorica flattened and bearing one or more spines on its dorsal surface (spines at the posterior margin of the lorica may or may not be present also). Foot distinct, jointed, ending in one or two toes

d1. Spines on the dorsal surface of the lorica eight or twelve (including four at the posterior margin); lorica subquadrate, rough, toothed at the edges; head covered by a chitinous shield . . . . . Polychætus

e1. Eight spines on the dorsal surface of the lorica

f1. Foot bearing two large dorsal spines or spurs 157, *P. collinsii* Gosse

f2. Foot without dorsal spines . . 158, *P. serica* Thorpe

e2. Twelve spines on the dorsal surface of the lorica; foot with two long dorsal spines

159, *P. subquadratus* Perty (Fig. 111)

d2. Two spines on the dorsal surface of the lorica, a very long one rising from the middle, a short one from near the posterior margin. Head covered with a large semicircular shield

160, *Stephanops bifurcus* Bolton

d3. One spine from the middle of the dorsal surface of the lorica; otherwise much like the last

161, *Stephanops longispinatus* Tatem (Fig. 112)

d4. One long spine from in front of the middle of the dorsal surface of the lorica; also four curved spines from the posterior margin, and a short median point at the anterior dorsal margin

162, *Brachionus* (?) *gleasonii* Up de Graff (Fig. 113)

c3. A broad, nearly circular projecting plate over the head, appearing like a halo. Lorica cylindrical or pyriform, covering both dorsal and ventral surfaces; not faceted nor bearing spines on the surface (though there may be spines at the posterior edge). Foot distinct; toes two

d1. Lorica pyriform, with a narrow neck, slightly prolonged behind into three subparallel acute spines. Foot with a toe-like spine above the two toes

163, *Stephanops lamellaris* Ehr. (Fig. 114)

d2. Lorica cylindric, with a distinct neck; dorsal plate prolonged behind, over the foot, as a spoon-like shield

164, *Stephanops muticus* Ehr.

c4. The very short foot ending in one, two, or more very slender, stiff, bristle-like toes; where more than one are present, these may be equal or unequal. Lorica cylindrical, fusiform, ovate, or conical, closed all around but open at each end, smooth, rather thin; frequently showing a tendency to be spirally curved or otherwise unsymmetrical in form; often with one or two longitudinal ridges. Jaws unsymmetrical. One eye

Family RATTULIDÆ

(The Rattulidæ are so badly in need of revision that it is difficult to give a usable key to the species. Moreover, it is certain that many species in addition to those hitherto recorded will be found in America.)

d1. One long, straight, bristle-like toe (if others are present, these are much shorter than the largest one) . Mastigocerca

e1. Lorica with a single marked ridge, passing from the mid-dorsal line of the lorica forward and to the right. No teeth or spines at the anterior margin of the lorica. A single long toe, with three or more minute "substyles" at its base

f1. Body fusiform ; ridge high (one-fourth the diameter of the body) . . . . . 165, *M. carinata* Ehr. (Fig. 115)

f2. Body fusiform ; ridge low . . . 166, *M. rattus* Ehr.

f3. Body cylindrical, elongated (length about four or five times the greatest diameter), slightly enlarged in front. Ridge low, hardly noticeable. Toe about the length of the lorica . . . . . 167, *M. elongata* Gosse (Fig. 116)

e2. Lorica with two parallel longitudinal ridges close together, with a groove between them. No teeth at the anterior margin of the lorica

f1. The two ridges extending three-fourths the length of the body, which is fusiform in shape ; toe very long, straight 168, *M. bicristata* Gosse (Fig. 117)

f2. The two parallel ridges close together and extending only one-half the length of the lorica ; body shorter, ovoid, or oblong in side view . 169, *M. mucosa* Stokes (Fig. 118)

e3. Lorica without a ridge, cylindrical, ovate, or conical. (See also No. 167, *M. elongata*)

f1. One or more teeth or spines present at the anterior margin of the lorica

g1. Two unequal teeth or spines at the anterior margin of the lorica ; body long-fusiform 170, *M. bicornis* Ehr. (Fig. 119)

g2. Two sharp, slender, equal spines close together at the anterior margin of the lorica ; body a cone, largest in front and tapering to a toe about one-fourth the length of the body . 171, *M. birostris* Minkiewicz (Fig. 120)

g3. A single large median tooth projecting over the head from the anterior dorsal margin of the lorica. Body cylindrical, somewhat curved ; toe little more than half as long as the body 172, *M. capucina* Wierz. & Zach. (Fig. 121)

g4. A single short broad median tooth from the anterior dorsal edge of the lorica. Body ovate-fusiform, nearly symmetrical, constricted anteriorly to form a cylindrical neck. Toe not so long as the body 173, *M. multicrinis* Kellicott (Fig. 122)

f2. Anterior dorsal margin of lorica smooth, without teeth

g1. Body very broad, ovate, compressed dorso-ventrally, unsymmetrical ; toe four-fifths the length of the body 174, *M. lata* Jennings (Fig. 123)

g2. Body short and thick, arched dorsally, nearly flat ventrally ; lateral antennæ, at the posterior lateral parts of the lorica, protected by two prominent projecting spines ; toe longer than the body 175, *M. bicuspes* Pell. (Fig. 124)

d2. Two equal bristle-like toes; these not more than half the length of the body . . . . . Rattulus

e1. Lorica long-cylindrical, curved; anterior margin of the lorica with a single prominent tooth on the left side, and with a number of crenulations; toes very nearly half the length of the body, each with two substyles at the base

176, *R. tigris* Müller (Fig. 125)

e2. Body shorter, cylindrical, with two deep furrows encircling it just in front of the middle. Toes very short (less than half as long as the body is thick), and frequently retracted within the lorica, so as to be concealed

177, *R. sulcatus* Jennings (Fig. 126)

d3. Two unequal bristle-like toes, the shorter being more than half as long as the longer. (Additional short substyles may be present) . . . . . Cœlopus (or Diurella?)

e1. Body short and thick (about half as thick as long); curved, with a ridge on the right side; one or two short teeth at the anterior margin of the lorica; longest toe almost or quite half the length of the body, the other little shorter; four substyles in addition to the two toes

178, *C. porcellus* Gosse (Fig. 127)

e2. Like the last, but body only about one-fourth as thick as it is long . . . . . 179, *C. tenuior* Gosse

e3. No teeth at anterior margin of lorica; body curved, cylindrical or fusiform; no ridge; the two toes nearly equal, not quite so long as the body is thick

180, *C. brachyurus* Gosse (Fig. 128)

c5. Lorica cleft down the middle of the back by a fissure, whose sides are united by membrane; open at both ends for the projection of the head and foot. Toes blade-shaped

Family SALPINADÆ

d1. Lorica only slightly developed, covering only the dorsal half of the body; median fissure not strongly marked (resembling the species of Furcularia, Nos. 117–121). One eye Diascliza

e1. Minute, swiftly moving; body short, cuneiform or cylindrical; head broad; lorica covering only the posterior third of the body; median fissure broad, inconspicuous

181, *D. lacinulata* O. F. M. (Fig. 129)

e2. Larger, body laterally compressed, arched dorsally; toes equal in length to the height of the body, curved toward the dorsal side . . . 182, *D. semiaperta* Gosse (Fig. 130)

d2. Lorica well developed, an oblong box enclosing the body, open at both ends and distinctly cleft down the middle of the back; furnished with spines or teeth at the anterior or posterior margins or both; one eye . . . . . Salpina

e1. Spines or teeth on the lorica as follows: two anterior dorsal, two anterior ventral, one (median) posterior dorsal, two posterior ventral. (Spines all rather short, tooth-like)
183, *S. mucronata* Ehr. (Fig. 131)

e2. Spines or teeth as follows: no anterior dorsals, two anterior ventral, one posterior dorsal, two posterior ventral. (The four following species are distinguished, all having the above characters; it is possible that they should be considered mere variations of a single species, *S. ventralis* Ehr.)

f1. Anterior ventral spines short and straight; posterior spines all short, the ventral ones recurved
184, *S. brevispina* Ehr.

f2. Anterior ventral spines very short, posterior dorsal spine short, decurved; posterior ventral pair longer than the posterior dorsal; lorica with a stippled collar
185, *S. ventralis* Ehr.

f3. Anterior ventral spines short, straight; posterior spines all long and straight, the ventral ones much the longer; lorica surface not stippled; dorsal cleft wide
186, *S. macracantha* Gosse

f4. Anterior ventral spines short, incurved; posterior dorsal conical, short, arched; posterior ventral long, stout, incurved; dorsal cleft narrow; lorica frequently stippled
187, *S. eustala* Gosse (Fig. 132)

e3. No posterior spines; anterior dorsal pair *very long;* anterior ventral pair also long and slender, but only about half as long as the dorsal ones. Lorica broad
188, *S. macrocera* Jennings (Fig. 133)

d3. Lorica as in *d2*, but without spines; the eye lacking
Diplax

e1. Body triangular in section; lateral outline of lorica nearly ovate, but strongly arched dorsally and nearly flat ventrally
189, *D. trigona* Gosse

e2. Body much compressed, long and narrow in dorsal view, in side view nearly a parallelogram. 190, *D. compressa* Gosse

c6. Foot very long, of several joints; the two toes very long; lorica entire (not cleft dorsally nor ventrally), vase-shaped or compressed, not bearing spines. Head furnished with a chitinous covering. Eye one

d1. Lorica vase-shaped, faceted, and with surface roughened; head retractile within a chitinous cap; eye one; foot bearing two spines dorsally; foot and toes together nearly or quite twice the length of the body . . . . . Dinocharis

e1. A short spine dorsally between the two toes
191, *D. pocillum* Ehr. (Fig. 134)

e2. No spine between the two toes . 192, *D. tetractis* Ehr.

d2. Lorica somewhat vase-shaped, thin, smooth, and transparent; head with a thin chitinous covering; eye very close to or upon the mastax . . . . . Scaridium

e1. Body nearly cylindrical or slightly compressed laterally; body, foot, and toes of about equal length 193, *S. longicaudatum* Ehr. (Fig. 135)

e2. Body broad, ovate or pear-shaped; toes about as long as body and foot together 194, *S. eudactylotum* Gosse (Fig. 136)

c7. Lorica of two dissimilar plates, one dorsal and one ventral, the former usually larger and arched (except in No. 201), the latter flat or slightly convex. Large transparent rotifers, with a single eye. Foot jointed, the two toes large, usually blade-shaped Euchlanis

d1. Lorica oval or ovate, gently arched above, nearly flat below; transverse section a low segment of a circle

e1. Ventral plate with a flange projecting laterally from its junction with the body; anterior dorsal edge with a broad gap having a straight bottom (Fig. 138); hind dorsal edge notched . . . . . 195, *E. dilatata* Ehr. (Fig. 137)

e2. Ventral plate without a lateral flange; anterior dorsal margin with a small subsquare notch 196, *E. deflexa* Gosse

d2. Lorica a long, narrow oval or an ellipse, depressed; anterior dorsal edge membranous; transverse section a low circular segment; ventral plate elliptical and broadest at the hind end 197, *E. lyra* Hudson

d3. Lorica broadly oval or ovoid, constricted near the middle, the dorsal plate much wider than the ventral and turned downward and inward . 198, *E. pyriformis* Gosse (Fig. 139)

d4. Lorica roof-shaped, with sloping sides; not rising to a ridge; cleft for a short distance behind. Ventral plate flat, smaller in outline than the dorsal. A small species, 199, *E. oropha* Gosse

d5. Lorica with a high median dorsal keel; lateral edges of the lorica extending laterally into two wide shelves, so that the animal seems to have three keels, and is triangular in section. Outline from above ovoid . . . . 200, *E. triquetra* Ehr.

d6. Dorsal plate carinate; lorica ovate, flask-shaped; foot four-jointed; toes more than half the length of the lorica 201, *E. ampuliformis* Herrick (*E. propatula*) Gosse (?) (Fig. 140)

c8. Lorica of two plates, the ventral one nearly flat, the dorsal one slightly or considerably elevated. The two plates separated by a deep lateral furrow covered with flexible membrane. Body ending posteriorly in either one or two large rod-shaped toes (the foot proper being short and inconspicuous). One eye Family CATHYPNADÆ

d1. Toes two

e1. Lorica subcircular or broadly ovoid, with a wide and deep lateral furrow . . . . . Cathypna

f1. Lorica rather flattened, dorsal and ventral plates nearly equal in size, broadly oval in outline ; toes two-fifths as long as the lorica, each with a distinct angle or shoulder at the side, near the tip, and with a small sharp claw, which continues the inner side of the toe 202, *C. luna* Ehr. (Fig. 141)

f2. Lorica ovoid, the dorsal plate ending behind in a subsquare plate with its posterior lateral corners extended into distinct angles. Toes rod-shaped, very long (almost as long as the lorica) . . 203, *C. leontina* Turner (Fig. 142)

f3. Very large (.31 mm. in length) ; lorica long ovoid or truncate elliptical in form ; dorsal plate projecting posteriorly as a semicircular plate over the foot. Toes about half the length of the lorica . . 204, *C. ungulata* Gosse

e2. Lorica longer, usually a long ellipse, open in front ; lateral furrow not pronounced . . . . . Distyla

f1. Dorsal plate faceted, *i.e.*, marked off into polygonal areas

g1. Dorsal plate ending behind in a quadrangular projection with nearly parallel sides 205, *D. ohioensis* Herrick (Fig. 143)

g2. Dorsal plate ending behind in two sharp points separated by a broad gap . 206, *D. stokesii* Pell (Fig. 144)

g3. Dorsal plate ending behind in a single sharp point 207, *D. ludwigii* Eckstein (Fig. 145)

g4. Dorsal plate not ending behind in projections, but bearing in the posterior lateral region two short projecting teeth, protecting two lateral antennæ. Foot conspicuous, three-jointed 208, *D. spinifera* Western (Fig. 146)

f2. Dorsal and ventral plates marked with small crescentic elevations arranged in somewhat regular patterns. Lorica of truncate elliptical form, without posterior projections 209, *D. signifera* Jennings (Fig. 147)

f3. Lorica flexible, smooth, or marked with irregular wrinkles or longitudinal folds

g1. Small, lorica parallel-sided, soft, with irregular wrinkles and longitudinal folds . . 210, *D. flexilis* Gosse

g2. Lorica long, flexible, nearly parallel-sided when extended (Fig. 148) ; when completely retracted broader in front and ending in two strong incurved points (Fig. 149). Dorsal surface with a few irregular longitudinal folds . 211, *D. gissensis* Eckstein (Figs. 148 and 149)

g3. Lorica soft, much broader behind and tapering forward to the narrow head when extended; broad ovate, truncate, when retracted. Toes short, with claw about one-third the length of the toe . 212, *D. inermis* Gosse

d2. One rod-shaped toe . . . . . Monostyla

e1. Lorica broad ovate, flat, projecting anteriorly into two long sharp, outwardly curved spines, separated by a narrow rounded notch . . . . . 213, *M. quadridentata* Ehr. (Fig. 150)

e2. Lorica ovate, toe broadly fusiform 214, *M. closterocerca* Schmarda (Fig. 151)

e3. Lorica without spines; toe rod-shaped or tapering to the tip

f1. Lorica broadly ovate, with a crescentic concavity in front when the head is retracted. Toe with parallel sides 215, *M. lunaris* Ehr. (Fig. 152)

f2. Lorica ovate, without a crescentic concavity in front when the head is retracted, but nearly truncate. Toe short, rod-like . . . . 216, *M. cornuta* Ehr. (Fig. 153)

f3. Dorsal plate high arched, ventral somewhat convex; anterior dorsal edge of lorica with a shallow, rounded or quadrate notch; ventral plate with a much deeper, broader notch . . . . . 217, *M. bulla* Gosse (Fig. 154)

f4. Lorica ovate; two anterior lateral points when the head is retracted. Ventral plate flexible, with irregular longitudinal folds . . . . 218, *M. arcuata* Bryce (Fig. 155)

f5. Lorica subcircular, but little longer than broad; two inwardly curved sharp points at the anterior edge when the head is retracted; toe rod-like, ending in two short claws projecting from between two minute spines 219, *M. robusta* Stokes (Fig. 156)

f6. Lorica subovate, with a straight anterior margin when contracted (insufficiently described) 220, *M. truncata* Turner

f7. Lorica broadly ovate, truncate, rounded dorsally. Dorsal plate strengthened by two diverging longitudinal ribs about equidistant from each other and from the lateral edges of the plate, rendering the anterior margin slightly angulate where they join it . . . 221, *M. ovata* Forbes

e4. Lorica a soft, flexible, corrugated skin, hardly deserving the name of lorica. Body oblong, subcylindric. Toe rod-shaped, with a short claw . . . . 222, *M. mollis* Gosse

c9. Lorica of a single piece, like a coat, covering only the anterior half of the dorsal surface of the body, or less; foot long, jointed, with two minute toes . . . . . Cochleare

d1. Lorica three-sided . . . 223, *C. turbo* Gosse (Fig. 157)

c10. Head surmounted by an arched chitinous shield, appearing in side view like a hook; lorica either arched, and compressed laterally, or dorso-ventrally flattened

d1. Lorica arched, somewhat compressed laterally, so as to be higher than wide; open behind and in front, and sometimes open on the ventral side. Minute, inconspicuous rotifers
Colurus

e1. Lorica ovate as viewed from above; produced caudally (as seen in dorsal view) into two acute spines, separated by a deep sinus; ventral surface of lorica cleft
224, *C. deflexus* Ehr. (Fig. 158)

e2. Lorica not cleft ventrally; excavate behind, so as to form two teeth with a shallow notch between them
225, *C. bicuspidatus* Ehr. (Fig. 159)

e3. Pear-shaped, widest behind, in dorsal view; ventral surface cleft; caudal notch very shallow, between two short terminal points; foot and toes three-fourths the length of the lorica . . . . . 226, *C. caudatus* Ehr.

e4. Ovate in dorsal or lateral view, the posterior end rounded, without points; lorica cleft ventrally. Foot very small
227, *C. obtusus* Gosse (Fig. 160)

e5. Elongate-ovate in dorsal view; caudal margin rounded, without cleft or points; ventral cleft interrupted in front of the middle, so that the openings for the head and foot are not continuous . . . . . 228, *C. agilis* Stokes (Fig. 161)

e6. Lorica ovate in dorsal view, high behind, low in front; a long, stiff, pointed, hyaline crest extending backward and upward from the middle of the anterior dorsal edge of the lorica . . . . . 229, *C. cristatus* Rousselet (Fig. 162)

d2. Height and width of lorica about the same; lorica forming an ovate box with surface marked into areas; a thin ridge on the mid-dorsal line; a similar ridge on the mid-ventral line from the anterior margin to about the middle of the length
230, *Metopidia salpina* Ehr. (Fig. 163)

d3. Lorica flattened, wider than high, usually turtle-like in appearance; open only in front and behind, not along the ventral middle line . . . . . Metopidia

e1. Outline of lorica varying from elliptical through oval and ovate to orbicular, but without teeth, spines, or prominent angles (except at the sides of the foot and head, where angles are necessarily formed, owing to the openings in the lorica)

f1. Lorica nearly circular, much depressed; dorsal plate with a very low rounded median ridge and with a submarginal line of corrugation . . . . 231, *M. solidus* Gosse

f2. Lorica oval or ovate, much depressed, evenly rounded

above ; ventral plate excavate behind for the foot ; eyes two . . . . . 232, *M. lepadella* Ehr. (Fig. 164)

f3. Similar to the last, but with four eyes. (Perhaps only a variation of the last) . . . . . 233, *M. bractea* Ehr.

f4. Lorica elliptical or ovately oblong ; toes long, slender ; eyes two or four ; foot of three nearly equal joints 234, *M. oblonga* Ehr. (Fig. 165)

f5. Like the last (of which it is probably only a variation), but with the third joint of the foot equal in length to the other two together ; the two toes protruded between two minute lateral spines . 235, *M. dentata* Turner (Fig. 166)

f6. As in *M. oblonga*, but with the anterior margin of the lorica covered with points, so as to form a stippled collar ; the angles of the lorica at the sides of the head very sharp, so as almost to form spines (variation of *M. oblonga?*) 236, *M. collaris* Stokes (Fig. 167)

e2. Lorica rhomboid-ovate in outline ; dorsal plate roof-shaped, lower behind and ending in an obtuse point ; ventral surface flat . . . . . 237, *M. rhomboides* Gosse

e3. Lorica ovate, ending behind in an acute point 238, *M. acuminata* Ehr.

e4. Lorica with three wide, thin wings, one dorsal and two lateral ; the dorsal view nearly circular 239, *M. triptera* Ehr.

e5. Lorica broad behind, having four prominent angles, two lateral and two posterior 240, *M. ehrenbergii* Perty (Fig. 168)

e6. Lorica with two great spines at the anterior dorsal margin ; these separated by a narrow median notch 241, *M. cornuta* Schmarda (Fig. 169)

ANN ARBOR, MICH., Feb. 5, 1901.

SOME OF THE MORE IMPORTANT LITERATURE ON THE ROTATORIA.

I. MOST IMPORTANT GENERAL SYSTEMATIC WORKS.

EHRENBERG, C. G. Die Infusionsthierchen als vollkommene Organismen. Leipzig. 1838. (Still one of the most important works.)

HUDSON, C. T., and GOSSE, P. H. The Rotifera, or Wheel Animalcules. 2 vols., with supplement. London, Longmans, Green & Co. 1889. (Indispensable.)

JANSON, OTTO. Versuch einer Uebersicht über die Rotatorien-Familie der Philodinaeen. Beilage zum XII. Bande der *Abhdlg. d. Naturw. Vereins zu Bremen.* 1893. (Monograph of the Bdelloida.)

ROUSSELET, C. F. List of New Rotifers since 1893. *Journ. Roy. Micr. Soc.* pp. 450–458. 1893.

——— Second List of Rotifers since 1889. *Ibid.* pp. 10–15. 1897.

WEBER, E. F. Faune Rotatorienne du Bassin du Leman. *Revue Suisse de Zool.* Tome v, pp. 263–785, 25 plates. (Beautiful figures of many species.)

II. PAPERS ON AMERICAN ROTATORIA.

HEMPEL, A. A List of the Protozoa and Rotifera found in the Illinois River and Adjacent Lakes at Havana, Ill. *Bull. Ill. State Lab. of Nat. Hist.* Vol. v, Art. vi, pp. 301–388. 1898.

HERRICK, C. L. Notes on American Rotifers. *Bull. Sci. Lab. Denison Univ.* Vol. i, pp. 43–62. 1885.

JENNINGS, H. S. The Rotatoria of the Great Lakes and of Some of the Inland Lakes of Michigan. *Bull. Mich. Fish Commission.* No. 3, pp. 1–34. 1894.

——— Report on the Rotatoria. From A Biological Examination of Lake Michigan in the Traverse Bay Region. *Bull. Mich. Fish Commission.* No. 6, pp. 85–93. 1896.

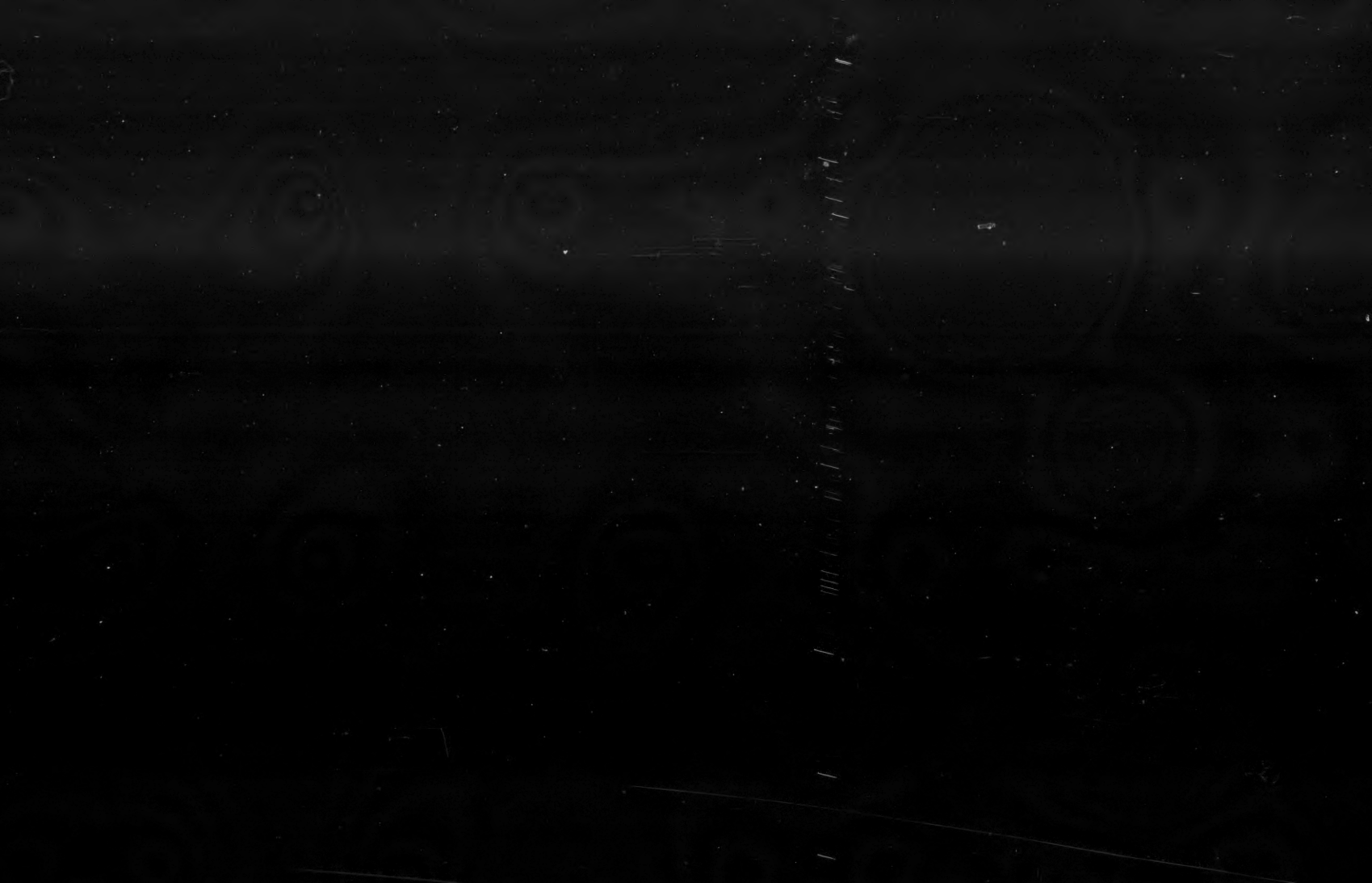
——— Rotatoria of the United States. *Bull. U. S. Fish Commission* for 1899. pp. 67–104. 1900. (List of all American species thus far recorded, with literature on American Rotifera.)

KELLICOTT, D. S. Partial List of the Rotifera of Shiawassee River at Corunna, Mich. *Proc. Amer. Soc. Micr.* Vol. x. 1888.

——— The Rotifera of Sandusky Bay. *Ibid.* Vol. xviii, pp. 155–164, 1896, and vol. xix, pp. 43–54, 1897.

TURNER, C. H. Notes upon the Cladocera, Copepoda, Ostracoda, and Rotifera of Cincinnati, with Descriptions of New Species. *Bull. Sci. Lab. Denison Univ.* Vol. vi, pt. ii, pp. 57–74. 1892.

III. SEE ALSO NUMEROUS RECENT PAPERS BY ROUSSELET (MOSTLY IN THE JOURNAL OF THE QUEKETT MICROSCOPICAL CLUB, IMPORTANT), HOOD, STENROOS, LEVANDER, BILFINGER, WIERZEJSKI, SCORIKOW, WESTERN, DADAY, AND OTHERS.



LIST OF FIGURES—PLATE I.

1. Floscularia pelagica, after Rousselet.
2. " edentata, after Weber.
3. " trilobata, after Hudson and Gosse.
4. " cornuta, after Weber.
5. " coronetta, after Weber.
6. " ornata, after Weber.
7. " campanulata, after Weber.
8. " algicola, after Hudson and Gosse.
9. Stephanoceros eichhornii, after Weber.
10. " " , jaws, after Hudson and Gosse.
11. Acyclus inquietus, after Leidy, from Hudson and Gosse.
12. Apsilus bipera, ventral view of head, after Foulke, from Stokes.
13. " bucinedax, after Stokes.
14. Melicerta ringens, in tube, after Hudson and Gosse.

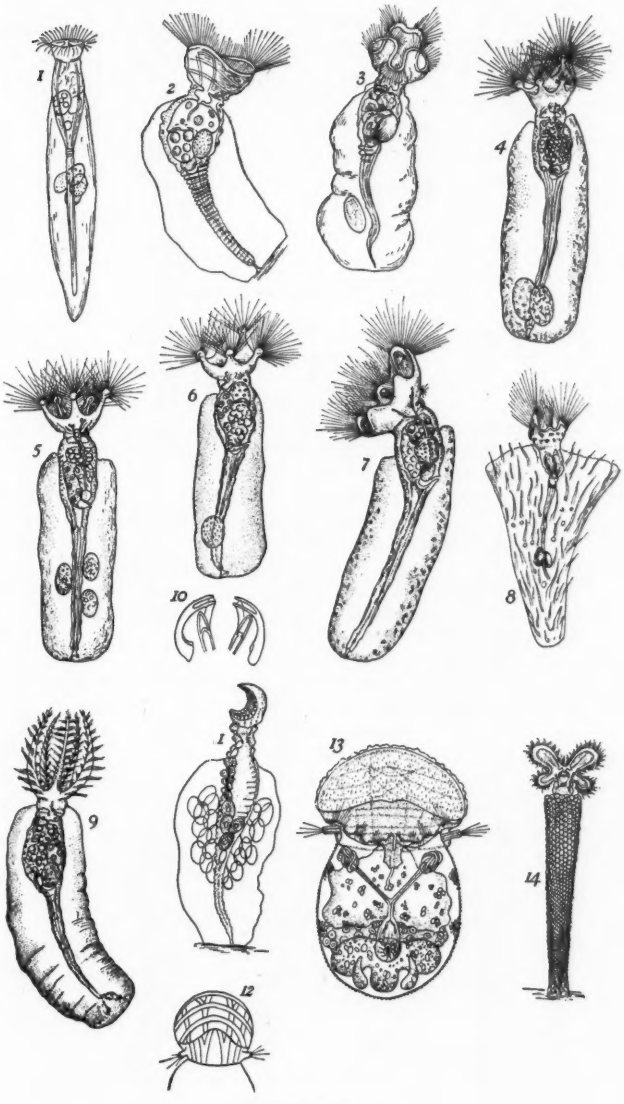


PLATE I.

LIST OF FIGURES—PLATE II.

15. Melicerta ringens, removed from tube, after Weber.
16. " " , jaws, after Hudson and Gosse.
17. " conifera, after Hudson and Gosse.
18. " janus, after Hudson and Gosse.
19. Limnias annulatus, after Weber.
20. Cephalosiphon limnias, after Weber.
21. Œcistes melicerta, side view.
22. " crystallinus, after Hudson and Gosse.
23. " intermedius, after Hudson and Gosse.
24. Megalotrocha semibullata, after Weber.
25. " alboflavicans, upper part, after Hudson and Gosse.
26. Conochilus volvox, after Hudson and Gosse.
27. " unicornis, after Weber.
28. Rotifer macroceros, after Weber.
29. " neptunius, after Weber.
30. " vulgaris (corona retracted), after Weber.
31. Foot of Rotifer trisecatus, after Weber.
32. " " " elongatus, after Weber.
33. " " " tardus, after Weber.

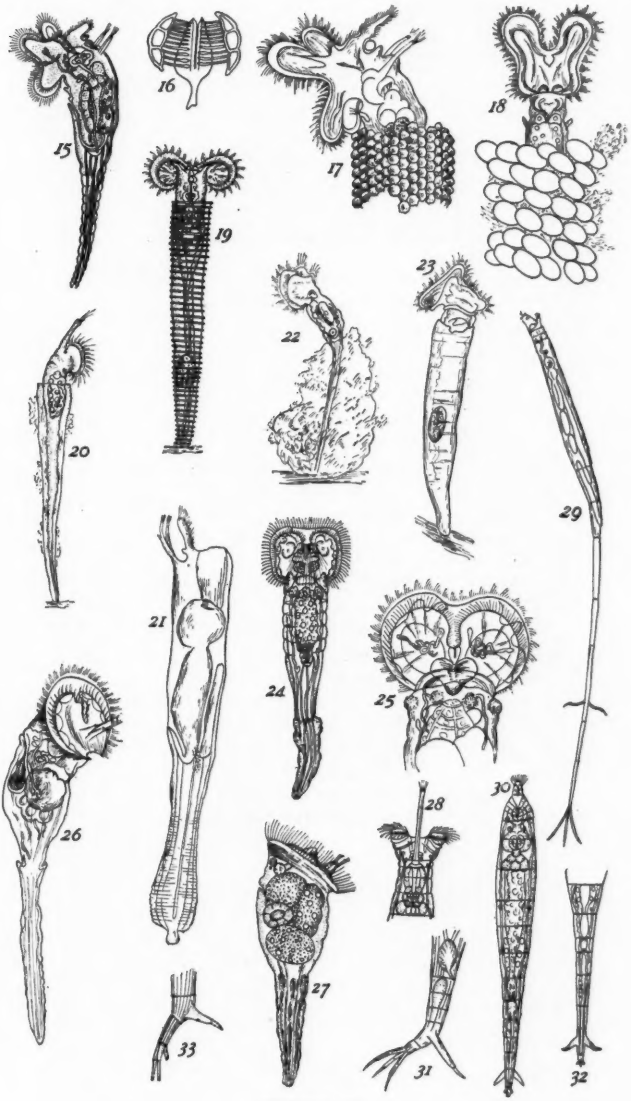


PLATE II.

LIST OF FIGURES — PLATE III.

34. Jaws of Philodina aculeata (ramate type), after Weber.
35. Philodina megalotrocha, after Weber.
36. Callidina eremita.
37. " papillosa, after Janson.
38. " elegans, jaws, after Janson.
39. " constricta, jaws, after Janson.
40. " " , spurs, after Janson.
41. " socialis, spurs, after Janson.
42. " musculosa, jaws, after Janson.
43. " " , spurs, after Janson.
44. Adineta vaga, anterior end, after Weber.
45. Microcodon clavus, after Weber.
46. Notommata monopus.
47. Rhinops vitrea, anterior end, after Hudson and Gosse.
48. Pedalion mirum, after Weber.
49. Polyarthra platyptera, after Ehrenberg.
50. Triarthra longiseta, after Ehrenberg.
51. Asplanchnopus myrmeleo, after Weber.
52. Asplanchna ebbesbornii, side view, after Hudson and Gosse.
53. " herrickii, after Wierzejski.
54. " brightwellii, jaws (incudate type), after Wierzejski.
55. " girodi, jaws, after Wierzejski.
56. Ascomorpha hyalina, after Kellicott.
57. " ecaudis, after Hudson and Gosse.

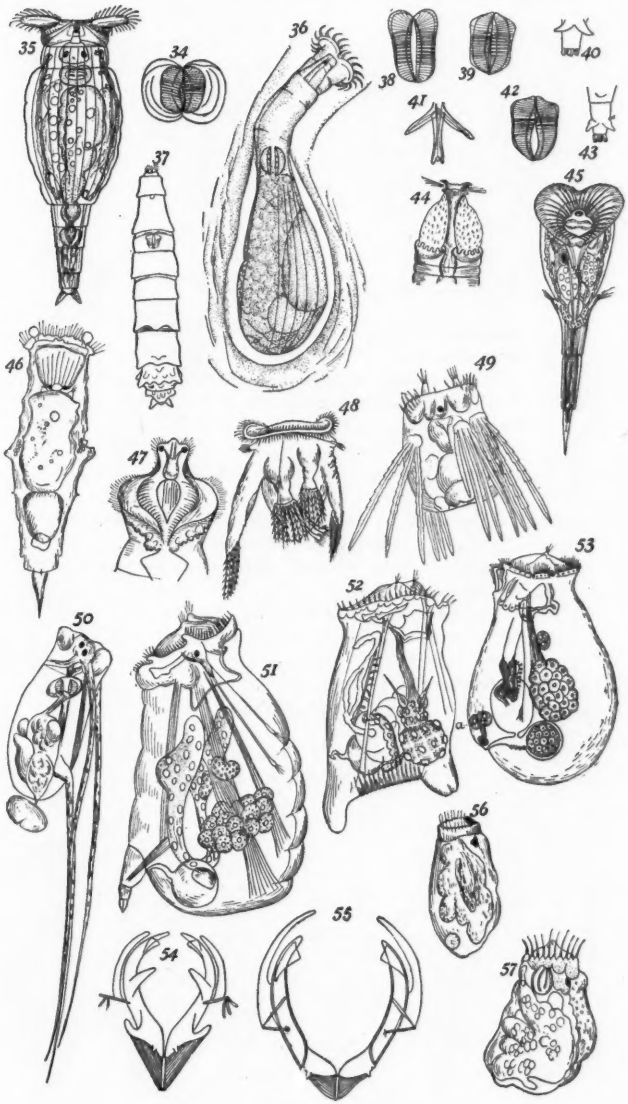


PLATE III.

LIST OF FIGURES—PLATE IV.

58. Anarthra aptera, after Hood.
59. Synchæta stylata, after Wierzejski.
60. " tremula, after Hudson and Gosse.
61. Triphylus lacustris, after Western.
62. Cyrtonia tuba, after Rousselet.
63. Hydatina senta, after Weber.
64. Notops clavulatus, after Hudson and Gosse.
65. " pelagicus.
66. Taphrocampa saundersiæ, after Hudson and Gosse.
67. " annulosa, after Hudson and Gosse.
68. " selenura, toes, after Hudson and Gosse.
69. Copeus copeus, after Ehrenberg.
70. " pachyurus, after Weber.
71. " cerberus, after Hudson and Gosse.
72. " americanus, after Pell.
73. Notommata tripus, after Stokes.
74. " brachyota, after Weber.
75. " truncata.
76. " collaris, after Ehrenberg.
77. " aurita, after Hudson and Gosse.

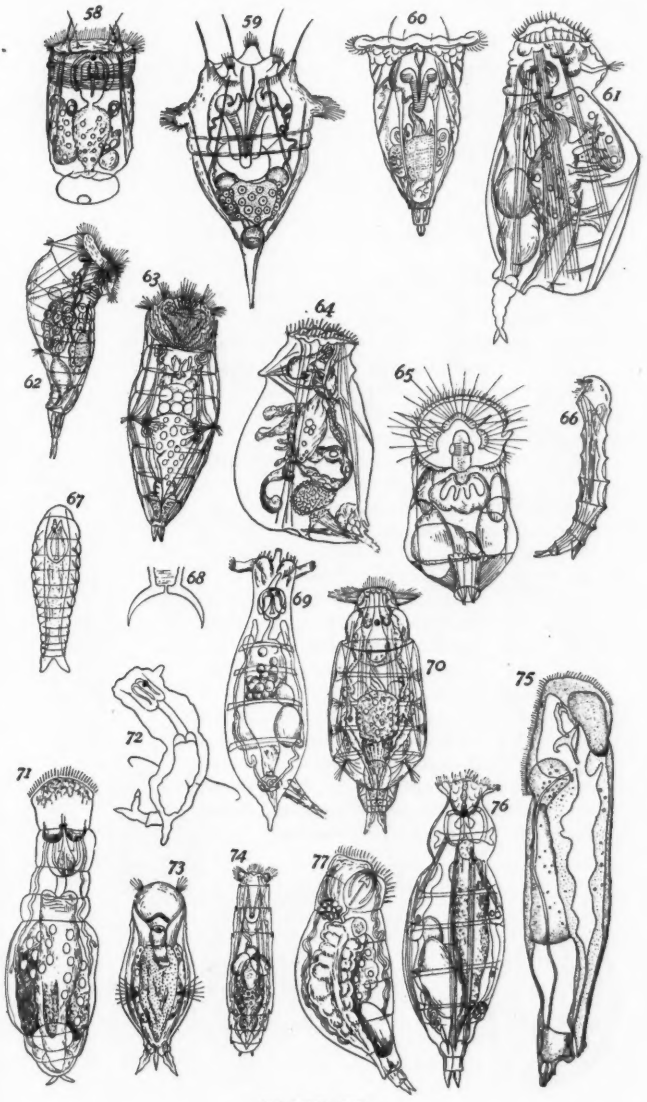


PLATE IV.

LIST OF FIGURES — PLATE V.

78. Notommata cyrtopus, after Hudson and Gosse.
79. " torulosa, after Cohn, from Hudson and Gosse.
80. Proales felis, after Hudson and Gosse.
81. " sordida, after Hudson and Gosse.
82. " micropus, after Hudson and Gosse.
83. " decipiens, after Weber.
84. " gibba, after Ehrenberg.
85. Furcularia forficula, after Weber.
86. " gracilis, after Hudson and Gosse.
87. " gibba, after Ehrenberg.
88. Triophthalmus dorsualis, after Ehrenberg.
89. Eosphora aurita, after Ehrenberg.
90. Diglena grandis, after Hudson and Gosse.
91. " forcipata, after Ehrenberg.
92. " circinator, after Hudson and Gosse.
93. " caudata, after Hudson and Gosse.
94. " catellina, after Weber.
95. " biraphis, after Hudson and Gosse.
96. Anapus ovalis.
97. Anuræa hypelasma, after Hudson and Gosse.
98. " cochlearis, after Weber.
99. " aculeata, after Hudson and Gosse.
100. Notholca longispina, lorica, after Hudson and Gosse.
101. Pterodina patina, after Hudson and Gosse.
102. " reflexa, after Rousselet.

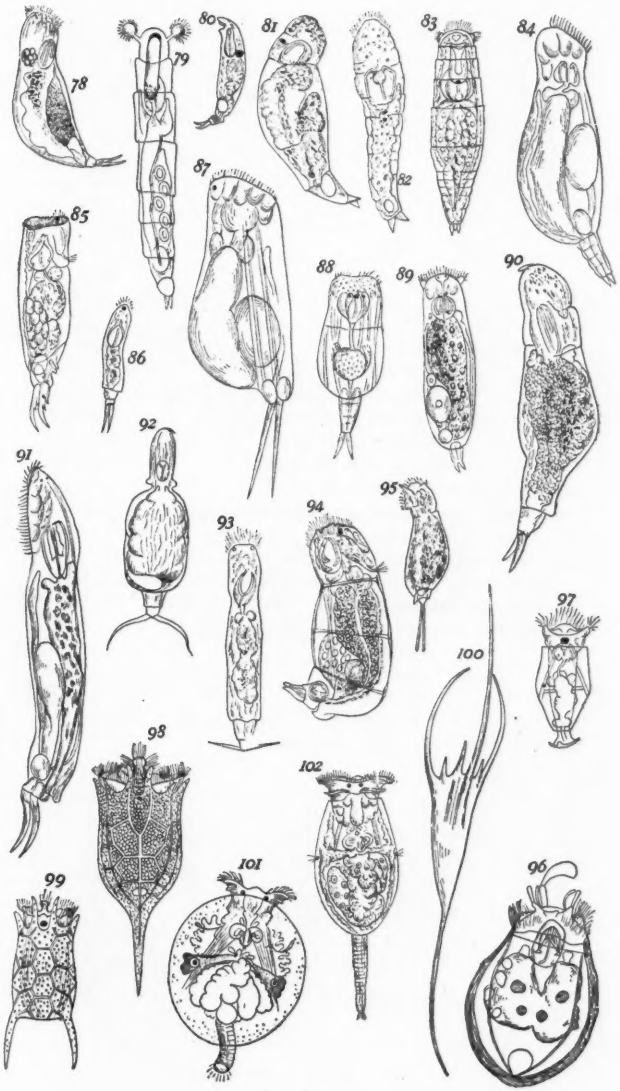

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PLATE V.

LIST OF FIGURES — PLATE VI.

103. Brachionus bakeri.
104. " punctatus, after Hempel.
105. " mollis, after Hempel.
106. Pleosoma lenticulare, after Wierzejski.
107. " truncatum, after Weber.
108. " hudsoni, after Wierzejski.
109. Gastropus stylifer, after Weber.
110. Noteus quadricornis, after Hudson and Gosse
111. Polychætus subquadratus.
112. Stephanops longispinatus, after Weber.
113. Brachionus (?) gleasonii, after Vorce, from Hudson and Gosse.
114. Stephanops lamellaris, after Weber.
115. Mastigocerca carinata.
116. " elongata.
117. " bicristata.
118. " mucosa.
119. " bicornis.
120. " birostris, after Minkiewicz.

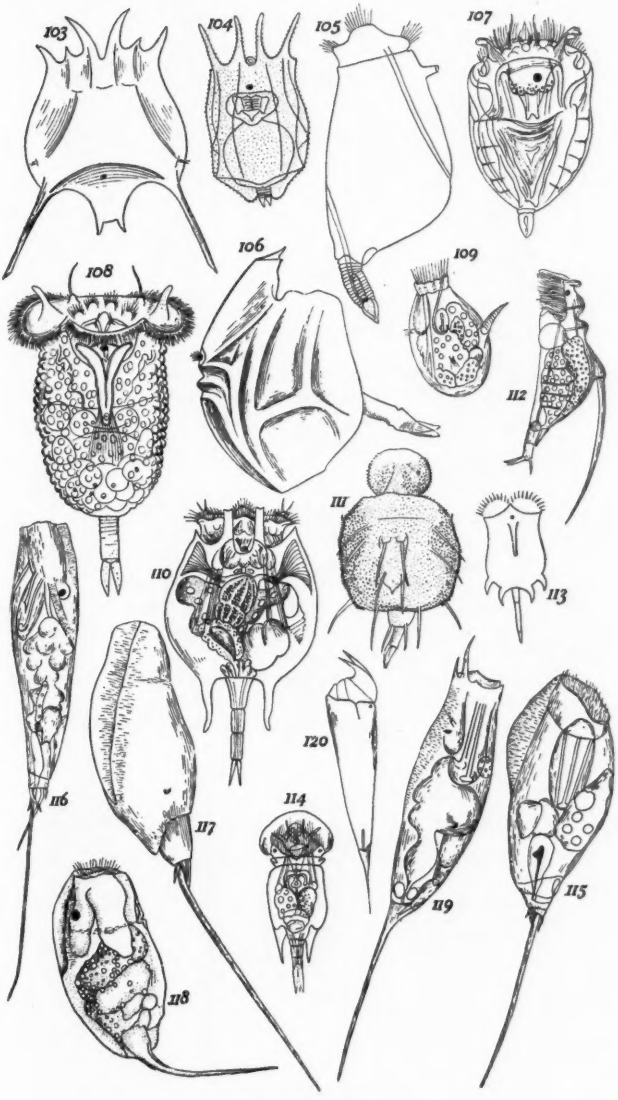
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PLATE VI.

LIST OF FIGURES — PLATE VII.

121. Mastigocerca capucina, after Wierzejski.
122. " multicrinis, after Kellicott.
123. " lata.
124. " bicuspes.
125. Rattulus tigris.
126. " sulcatus.
127. Coelopus (?) porcellus.
128. " brachyurus.
129. Diaschiza lacinulata, after Weber.
130. " semiaperta, after Hudson and Gosse.
131. Salpina mucronata, after Hudson and Gosse.
132. " eustala, after Hudson and Gosse.
133. " macrocera.
134. Dinocharis pocillum, after Hudson and Gosse.
135. Scaridium longicaudatum, after Weber.
136. " eudactylotum, after Hudson and Gosse.

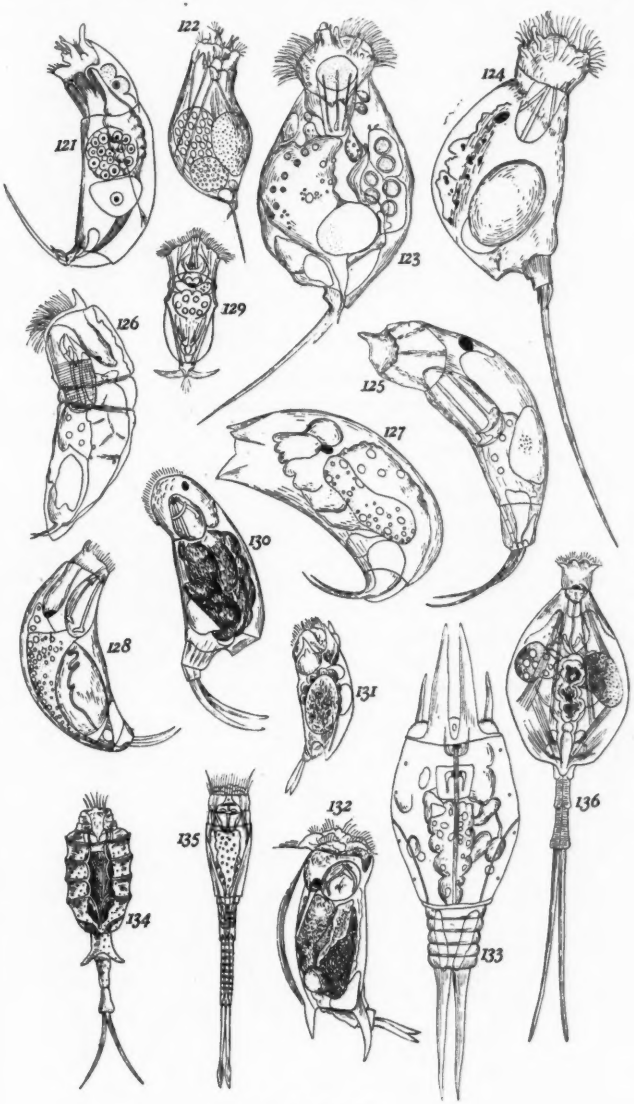

PLATE VII.

LIST OF FIGURES — PLATE VIII.

137. Euchlanis dilatata, after Hudson and Gosse.
138. " " , anterior dorsal edge of lorica, after Hudson and Gosse.
139. " pyriformis, after Hudson and Gosse.
140. " ampuliformis, after Herrick.
141. Cathypna luna.
142. " leontina.
143. Distyla ohioensis.
144. " stokesii.
145. " ludwigii.
146. " spinifera, after Western.
147. " signifera.
148. " gissensis, partly extended.
149. " " , retracted.
150. Monostyla quadridentata.
151. " closterocerca.
152. " lunaris.

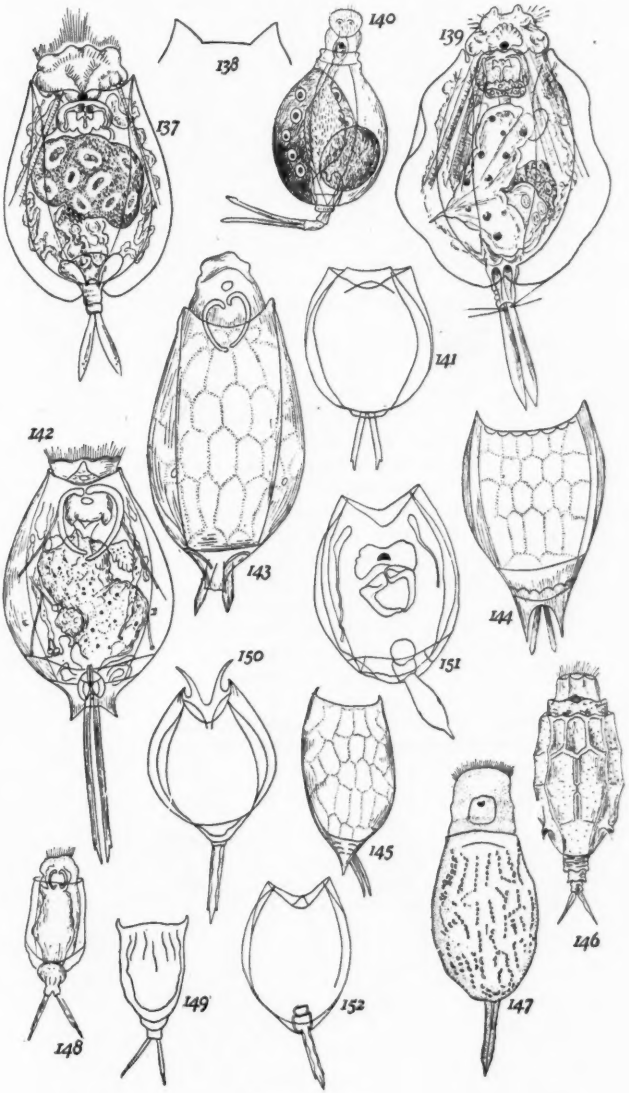

PLATE VIII.

LIST OF FIGURES — PLATE IX.

153. Monostyla cornuta.
154. " bulla.
155. " arcuata.
156. " robusta, after Stokes.
157. Cochleare turbo, after Hudson and Gosse.
158. Colurus deflexus, after Hudson and Gosse.
159. " bicuspidatus, after Hudson and Gosse.
160. " obtusus, after Hudson and Gosse.
161. " agilis, ventral view of lorica, after Stokes.
162. " cristatus, after Rousselet.
163. Metopidia salpina, after Weber.
164. " lepadella, after Ehrenberg.
165. " oblonga, after Ehrenberg.
166. " dentata, after Turner.
167. " collaris, after Stokes.
168. " ehrenbergii.
169. " (?) cornuta, after Schmarda.
170. Malleate jaws, after Hudson and Gosse.
171. Forcipate jaws, after Hudson and Gosse.

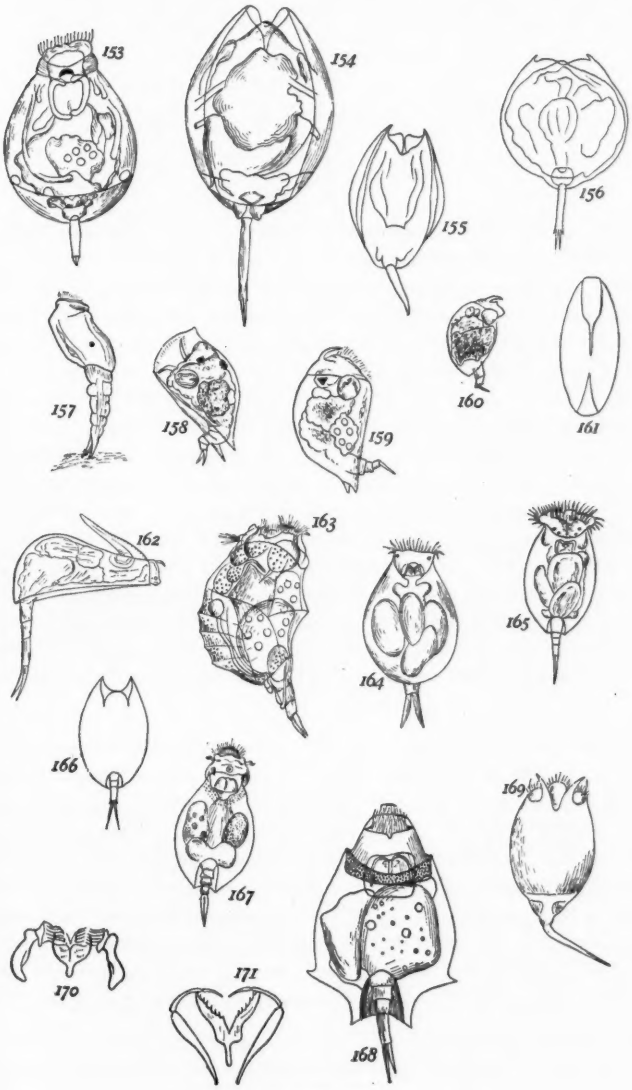
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PLATE IX.

REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

Reptilian Affinities of Primitive Mammals. — Sixta[1] has investigated the osteology of the foot in monotremes with the view of ascertaining the affinities of this primitive group of mammals. The monotremes possess a humerus with an epicondyloid foramen like that in reptiles, especially in the fossil Dimetrodon. Their radius, ulna, and carpal elements are arranged on the primitive reptilian plan, and yet their front feet are not unlike those of some marsupials (Dasyurus). In the hind foot the astragalus and calcaneum resemble those of reptiles, and the foot, on the whole, is oriented as in that group. The tarsals are as numerous as in the marsupials, but their forms and positions are typically monotrematic. The structure of the hind foot indicates an intermediate position for the monotremes between reptiles and marsupials. This opinion is further supported by a large body of evidence drawn from other organs, such as the heart and chief blood vessels (Hochstetter), the brain (Ziehen, Smith), the copulatory organs (Gadow), the embryonic membranes (Semon), the teeth (Poulton, Cope, Osborn), and skull.

P.

Anatomical Miscellanies. — The three numbers of the *Hopkins Hospital Bulletin*[2] for April, May, and June are combined into a single part and devoted to a collection of some twenty-three essays, mostly anatomical. The series opens with Barker's address on the Study of Anatomy, delivered at the Rush Medical College in October, 1900. Bardeen describes a new carbon-dioxide freezing microtome, Born's wax-plate reconstruction method as used in the Anatomical Laboratory at Hopkins, and calls attention to the importance of ordinary dissection-room material in scientific study. The cold-storage method of preserving bodies for dissection is dwelt

[1] Sixta, V. Vergleichend-osteologische Untersuchung über den Bau der Füsse der Reptilien, Monotremen, und Marsupialier, *Zool. Anzeiger*, Bd. xxiv (1901), pp. 321–332.

[2] *Bulletin of the Johns Hopkins Hospital*, vol. xii, Nos. 121–122, 123, April–May–June, 1901.

upon by Kerr. Harrison discusses the occurrence of tails in man, and reports on an interesting case brought to his notice by Dr. Watson. Brush contributes notes on cervical ribs, and Walker gives an account of cases of hereditary anchyloses of phalangeal joints. The development of the pig's intestine is described by MacCallum, and the structure of the gall-bladder by Sudler; of a less anatomical character are Halsted's report on the effects of injecting bile into the pancreas, and Opie's account of the etiology of acute hemorrhagic pancreatitis. The axillary artery and its variations are described by Hitzrot, the blood vessels of the lymphatic glands by Calvert, and the anatomical origin of the lymphatics in the liver by Mall, who also contributes a note on the basement membranes of the kidney tubules. Lewis gives an account of the pectoralis major muscle in man. The development of the human diaphragm is fully described by Mall. Neurology is represented by Mellus's article on the bilateral relations of the cerebral cortex, Long's paper on the development of the nuclei of the pons, and Fowler's description of a model of the dentate nucleus of the cerebellum. The development of the generative tracts in white ants is described by Knower, and the modification of normal menstruation by Mosher. The series gives substantial evidence of the great quantity and high quality of advanced work done in the Hopkins Hospital. P.

The Position of the Centrosome in Resting Cells. — By a thorough study of the segmenting eggs in Ascaris, zur Strassen[1] has shown that at each resting stage the centrosome takes up a position between the nucleus and the center of the exposed surface of the blastomere, *i.e.*, lies in the axis of the cell near its distal pole. This position is always attained, even though it involves a considerable migration on the part of the centrosome. As similar conditions have been figured by other authors in the segmenting eggs of several animals, and as the centrosome in ordinary epithelium regularly occurs in this position, zur Strassen believes that the rule discovered by him for Ascaris may prove to be of general application for all kinds of epithelial tissue, including the blastoderms of eggs. These observations favor the view that epithelial cells possess a true polarity, but this polarity is not one which has arisen first in adult epithelia. As is shown by its occurrence in the early segmentation stages, it is a polarity that is fairly comparable with that

[1] Zur Strassen, O. Ueber die Lage der Centrosomen in ruhenden Zellen, *Archiv für Entwickelungsmechanik der Organismen*, Bd. xii (1901), pp. 134–161.

of a flagellate protozoan cell, the ancestor of the colony of cells from which the metazoan body is believed to have taken its origin. Thus zur Strassen regards the polarity of epithelial cells not as a newly acquired feature, but as an inherited one derived from forms as primitive, possibly, as the protozoa.

P.

The Intestine of Cetaceans. — Süssbach[1] has described in detail the structure of the intestine in a number of cetacean embryos recently collected by Kükenthal. In the toothed whales there is no division into a large and small intestine, and, except in Platanista, there is no cœcum present, structural conditions always observed in the baleen whales. The toothed whales always possess a simple mesentery, without any trace of the complications introduced in the baleen whales by the folding of the intestine about parts of the mesentery. The toothed whales have a relatively longer intestine than the baleen whales, but the configuration of the intestinal surface seems to be independent for the two groups; thus some of the toothed whales with short intestines have much the same kind of intestinal surface as that in the baleen whales, though a general rule was found to the effect that the shorter the intestine is, the more complicated are the folds on its surface. Notwithstanding this last circumstance, the condition of the intestine points to the complete separateness of the two groups of living cetaceans, the baleen and the toothed whales.

P.

Notes on Recent Fish Literature. — In the *Proceedings of the California Academy of Sciences* (Zoöl., Vol. II, Nos. 7, 8) Jordan and Snyder describe two very remarkable new genera of Japanese fishes. The one, Ereunias (grallator), is a cottoid, allied to Triglops, but without ventrals, and with the four lowermost pectoral rays developed as detached feelers, as in Trigla. The other genus, Draciscus (sachi), is like Podothecus, but with enormously developed dorsal and anal fins. It belongs to the Agonidæ.

In the same *Proceedings* Jordan and Starks describe three new fishes from Japan, *Snyderina yamanokami*, *Pomacentrus cœlestis*, and *Heptranchias deani*. Snyderina is a new genus of Scorpænidæ, allied to Prosopodasys. All these species are represented by admirable plates, the work of Mrs. Chloe Lesley Starks.

[1] Süssbach, S. Der Darm der Cetaceen, *Jenaische Zeitschrift*, Bd. xxxv (1901), pp. 495–542, Taf. XVI, XVII.

In the *Abhandlungen der Senchenbergischen Naturforschenden Gesellschaft* of Frankfurt (Vol. XXV, No. 2), Dr. Steindachner gives an account of the fishes collected by Dr. Kükenthal in Molucca and Borneo. Two hundred and eight species are enumerated, six of them new, most of these being well figured.

In the *Records of Australian Museum* (Vol. IV, No. 1), Mr. E. R. Waite discovers that the sharks of the genera Hemiscyllium and Chiloscyllium bring forth their young alive. He therefore very properly separates these genera from the Scylliorhinidæ as a distinct family, Hemiscylliidæ. The genus Orectolobus (Crossorhinus) is also viviparous, and is recognized as a distinct family, Orectolobidæ. A figure is given of *Hemiscyllium modestum*, and also of the Australian dogfish, *Squalus megalops*, a species which has a very close relative in Japan.

As fishes of Lord Howe's Island, Mr. Waite figures *Upeneus pleurostigma*, *Apogon norfolcensis*, *Iniistius cacatua*, *Chætodon tricinctus*, and *Monacanthius homensis*. We may note that the deep green color of the teeth of *Pseudoscarus guacamaia* and related species is not the result of staining through the food. It is inborn, unvarying, and a result of distinct specialization.

D. S. J.

An Elementary Book on Lepidoptera.[1] — This is really an excellent book, both in conception and in execution. Reversing the order of her title, Miss Dickerson deals in Part I with the butterflies. The monarch *Danais archippus* holds the place of honor, and its life history and structural characters are given accurately and with sufficient detail; the other species, twelve in number, with the exception of two swallowtails, Papilios, a white, Pieris, and a sulphur, Colias, are all closely allied nymphalids.

In Part II *Callosamia promethea* is made the starting point, and the twenty and more species that follow are Bombyces, *sensu lat.*, and Sphinges.

The treatment in both these parts is so happy that the omission of an adequate account of the life history of a blue, Lycæna, and of a skipper, hesperid, among the butterflies, and of two or more of the lower moths, is especially regrettable.

Part III is divided between a chapter on relationship, showing classification and ancestry of moths and butterflies, and practical suggestions how to collect, keep, and study butterflies and moths.

[1] Dickerson, Mary C. *Moths and Butterflies.* Boston, Ginn & Company, 1901. xviii + 344 pp., 244 illustrations.

The chapter on relationship is from its nature more open to criticism; it is, however, clear in statement and well balanced in proportion. The practical directions are adequate, though exception must be taken to the recommendation for mounting moths and butterflies in glass-covered tablets; a sealed mount for any object preserved for study — and specimens not for study should not be collected — is undesirable.

A short list of books for reference, a glossary, and an index are also given.

Throughout the book errors of statement — such as, 'the tussocks are very often included, by competent authorities it is to be presumed, in the Noctuidæ,' and that there is but one brood of the white-marked tussock each year — are infrequent.

The illustrations are more numerous than either the title or the list indicates, and they show to what good advantage the camera may be applied in nature study.

S. H.

Sesiidæ. — Mr. William Beutenmüller's long-expected monograph of the Sesiidæ of America north of Mexico appears in sumptuous form as Part VI of Vol. I of the *Memoirs of the American Museum of Natural History*. After a brief introduction there are sections on the position of the family, its characters, characters of the genera, synopsis of genera, historic review of generic names, habits of imago, mimicry of imago, characters of the larvæ, synopsis of larvæ, habits of larvæ, synopsis of food habits of larvæ, characters of pupæ, descriptions of genera and species with synopses of the species, and a bibliography.

Mr. Beutenmüller recognizes seventeen genera, 100 species, and ten varieties; one new species and one new variety are described. Of the eight plates, five are devoted to the imagoes and three to larval borings. The figures of the imagoes, though inconveniently arranged on the plates, are admirable; only five species and three varieties are unfigured. Text-figures showing structural details are also given.

A bibliography of more than thirty-five pages and with 542 titles would seem adequate, but is not sufficient to include all the works quoted in the body of the paper.

The date, March, 1901, on the cover is entirely unjustifiable; copies were not received until June, and were certainly not issued earlier than the end of May.

S. H.

Mosquitoes. — Dr. Howard's well-known interest in and practical studies of mosquitoes take form in a volume[1] that will be of great value to naturalists, physicians, and municipalities. After a brief introduction he treats, in turn, with mosquitoes in general, malaria and mosquitoes, the common mosquitoes of the genus Culex, the malarial mosquitoes of the genus Anopheles, mosquitoes and yellow fever, mosquitoes and filiariasis, other genera of North American mosquitoes, natural enemies of mosquitoes, remedies against mosquitoes, how to collect and preserve mosquitoes, and the classification of the United States mosquitoes.

Dr. Howard's style is clear and direct, though a little inclined to redundancy and to repetition. An occasional lack of precision of expression and of accuracy may be noted; mosquitoes, for instance, being held to include species that are not Culicidæ, and again to exclude forms always comprised within that family. Chapter VI, dealing with genera of North American mosquitoes other than Culex and Anopheles, mentions six "genera known to occur in the United States," but considers and refers to seven!

The illustrations are excellent; a few are original, but the greater number from the facile pencil of Miss Sullivan appeared in the Author's *Notes* in 1900. Figure 42 does not represent *Aëdes fuscus*, and in the *Notes* was attributed to *A. sapphirinus*.

S. H.

BOTANY.

Bergen's Foundations of Botany[2] is virtually a much-improved and enlarged edition of the author's *Elements of Botany*, which has been one of the most successful of recent elementary text-books. The author's intimate knowledge of the needs and limitations of high schools, gained by long experience as a teacher, is shown even more effectively in the present volume than in its predecessor, for the publishers have done their part much better than before, improving the illustrations as well as adding largely to their number and in other ways doing fuller justice to the plan of the book.

[1] Howard, L. O. *Mosquitoes.* How they live; how they carry disease; how they are classified; how they may be destroyed. New York, McClure, Phillips & Co., 1901. xv + 241 pp., pl., 50 figs.

[2] Bergen, Joseph Y., Instructor in Biology, English High School, Boston. *Foundations of Botany.* Boston, Ginn & Company, 1901. 12mo. xii + 412 + 257 pp., 12 pls., 306 figs.

A first part deals with the structure, functions, and classification of plants. Beginning with the seed and its germination, this part treats comparatively of the various organs of seed plants as regards their gross anatomy, histology, and physiology, then considers various types of cryptogams, and finally outlines the evolutionary history of the vegetable kingdom. Following this comes a part devoted to ecology, which ends with a brief discussion of the causes of organic evolution. The last third of the book consists of a key and flora in which are described nearly seven hundred species of plants available for study in the springtime. A *Handbook for the Use of Teachers* is published separately. This includes sixty-two pages of practical suggestions and references supplementary to the numerous directions for observations, experiments, and extra reading which are given in the text-book itself.

The book abounds in fresh, interesting facts illustrating the principles discussed. These, too, are presented in a way to be intelligible and significant to young people. It will lead them to many intellectual delights.

Comparatively few errors have been noticed, and these are for the most part such as will be readily detected by teachers who use the book. They may be misled, however, by the unqualified adoption of the calyx-adnate theory of inferior ovaries given in Chapters XV and XVIII. To say the least, this complicated view of the morphology of many flowers and fruits is open to serious question. The modern view which regards an inferior ovary simply as one imbedded in the torus accords much better with what is known of the development of flowers, and avoids much perplexity to the student of flower and fruit morphology.

FREDERICK LEROY SARGENT.

Notes. — Professor Jepson's *Flora of Western Middle California* (Berkeley, Cal., 1901, iv + 625 pp.), which covers a region already locally handled, is really an expression of the author's own success in a field recognition of species, and, as he is conscientious and has drawn up his descriptions from fresh material instead of compiling them or basing them on herbarium fragments, the book should be helpful.

Dennert's *Plant-life and Structure*, translated from the German by Clara L. Skeat, forms one of the "Temple Primers," of which The Macmillan Company are the American publishers. It is easier to say why some books see the light than others. This little book belongs in the second category.

Dr. Robinson's latest "Contribution from the Gray Herbarium of Harvard University," constituting No. 26 of the current volume of *Proceedings of the American Academy of Arts and Sciences*, includes synopses of Melampodium and Nocca (or Lagascea), and a number of additions to the Mexican flora, chiefly in the genus Eupatorium.

An enumeration of the plants known to grow on Mt. Rainier, by Piper, is published in *Mazama* for April. Flowering plants seem to disappear above 10,000 feet, at which elevation *Smelowskia ovalis* still occurs, and the timber line is at 6500 feet.

A considerable part of *Rhodora* for June is given to articles on Mt. Katahdin and its botany.

Fascicle 2 of the current volume of the *Mémoires de l'Institut Egyptien* is a contribution to the flora of Egypt, by E. Sickenberger. Though the fascicle bears date 1901, the preface is dated January 31, 1895.

Mr. J. M. Macouns's "List of the Plants of the Pribilof Islands," with notes on their distribution, has been reprinted from Part III of Jordan's *Fur Seals and Fur-seal Islands of the North Pacific Ocean.*

A paper on new spermatophytes from Mexico and Central America, by M. L. Fernald, constitutes No. 27 of the current volume of *Proceedings of the American Academy of Arts and Sciences.*

A thirteenth selection of new plants from Wyoming, by Aven Nelson, is published in the *Bulletin of the Torrey Botanical Club* for April.

The third of a numbered series of papers which Professor Sargent is publishing in the *Botanical Gazette* under the title "New or Little-known North American Trees," in the April number of that journal, adds a considerable number of species of Cratægus for the United States, and a new Alaskan Betula, and raises the Californian *Cupressus Goveniana pygmæa* to specific rank.

The forms commonly referred to *Ribes rubrum* have been passed in review by Hedlund in recent numbers of *Botaniska Notiser.*

The native plums form the subject of *Bulletin No. 87* of the Wisconsin Experiment Station, by Professor Goff.

A revision of thirty-five western and northern Antennarias of the plantaginifolia set, by Elias Nelson, has recently been separately distributed from the *Proceedings of the United States National Museum.*

Anatomical studies of Primulaceæ and Simarubeæ are contained in recent numbers of the *Annales des Sciences Naturelles.*

The Gardener's Chronicle for June 8 contains an illustrated article on the species of Platanus usually planted as street trees, etc.

The morphology and anatomy of Aloineæ is the subject of an illustrated paper by Hausen in the *Verhandlungen des Botanischen Vereins der Provinz Brandenburg* for 1900.

The grasses of Iowa are considered at length as to their biology, chemical composition, etc., by Pammel, Weems, and Lamson-Scribner, in *Bulletin No. 54* of the Iowa Agricultural College.

Professor Lamson-Scribner gives an account of some Arizona grasses — several of them described as new — in *Circular No. 32* of the Division of Agrostology of the United States Department of Agriculture.

A revised edition of *Bulletin No. 17* of the Division of Agrostology of the United States Department of Agriculture (Professor Lamson-Scribner's "American Grasses, II") has been issued from the Government press.

Mr. C. L. Shear publishes some notes on Fournier's Mexican species and varieties of Bromus in the *Bulletin of the Torrey Botanical Club* for April.

The coralloid rootlets of *Cycas revoluta* and their symbiosis are considered by A. C. Life in the *Botanical Gazette* for April.

Professor Shimek contributes a paper on the pteridophytes of Iowa to the current volume of the *Bulletin* of the laboratories of natural history of the State University of Iowa.

The eighty-two Alaskan Hepaticæ noted in Professor Evans's paper on the representatives of this group collected by the Harriman Expedition are increased by the addition of three others collected by Professor Setchell, in a list of species published in Nos. 6, 7 of *Zoe.*

A third series of preliminary diagnoses of new species of Laboulbeniaceæ, by Dr. Thaxter, is issued as No. 23 of the current volume of *Proceedings of the American Academy of Arts and Sciences.*

A convenient pocket host index for the commoner European parasitic fungi, by Dr. Lindau, is published by Gebrüder Borntraeger, of Berlin.

A revision of forty species of Hydnum, by H. J. Banker, appears in the April number of the *Bulletin of the Torrey Botanical Club.*

A report on the agricultural resources and capabilities of Hawaii, by Professor Stubbs, which constitutes *Bulletin No. 95* of the Office of Experiment Stations of the United States Department of Agriculture, contains reproductions of a number of excellent photographs of tropical plants and fruits.

The cultivation and manufacture of tea in British India and Ceylon is the subject of No. 2 of the current volume of *Beihefte zum Tropenpflanzer*, published in Berlin.

An illustrated article on breeding new wheats, at the Minnesota Experiment Station, is a prominent feature of *The World's Work* for May.

The manufacture of sago is illustrated in *Der Tropenpflanzer* for May.

"The Stock-poisoning Plants of Montana" is the title of an extensive illustrated paper by Chesnut and Wilcox, published as *Bulletin No. 26* of the Division of Botany of the United States Department of Agriculture.

The third volume of *Meddelanden fraan Stockholms högskolas botaniska institut*—an assembled series of papers by Professor Lagerheim and his associates — is especially interesting because of its mycological contents.

An illustrated catalogue of the plants of the Alpine garden "La Linnæa," of Bourg-St.-Pierre, has recently been issued by the director, M. Correvon, of Geneva.

An account of the botanic garden of the Czernowitz University, planted in 1877, is contained in the *Festschrift* of the recently celebrated quarter-centennial of the University.

A short illustrated article on the botanic gardens of Malta is published in the *Gardener's Chronicle* for May 4.

The *Youth's Companion*, than which no more potent medium could be desired, has undertaken to aid in creating a national sentiment which shall eventually result in the universal beautifying of the grounds of the rural schools of the United States.

CORRESPONDENCE.

Editor of the American Naturalist:

SIR, — In the course of recent bibliographical studies the writer has discovered a number of cases in which the names given to recently described American hydroids have been given to other species by previous writers. For three of these the writer is personally responsible, and takes the first opportunity to correct the errors. The other cases will be discussed later.

Halecium geniculatum Nutting. Hydroids from Alaska and Puget Sound. *Proceedings of the United States National Museum*, Vol. XXI, p. 744.

This name was used by Norman in a paper published in 1866, entitled "On the Hydrozoa (etc.) of the Hebrides," p. 196.

For this species the following name is now proposed: *Halecium washingtoni* Nutting.

Halecium robustum Nutting. Papers from the Harriman Alaska Expedition, XXI. The Hydroids, 1901, p. 182.

Allman gave this name to a species from Kergueland Bay. *Challenger Report.* The Hydroida, Part II, 1888, p. 10.

For this species I propose the following name: *Halecium harrimani* Nutting.

Thuiaria elegans Nutting. Papers from the Harriman Alaska Expedition, XXI. The Hydroids, 1901, p. 187.

Name preoccupied by Kirchenpauer. Nordische Gattungun und Arten von Sertulariden, 1884, p. 21.

This species will now be known as *Thuiaria kincaidi* Nutting. Named in honor of Mr. Trevor Kincaid, one of the members of the Harriman Expedition.

Judging from the numerous cases that have recently come to my attention of the use of preoccupied names in zoölogy, I am more and more of the opinion that it is unsafe to give descriptive specific names to forms belonging to long-established genera. It is safe to say that no one investigator has at his command all of the papers relating to any group of considerable size. The names which occur to a writer as particularly apt in a descriptive way are the very ones that have been most likely to appeal to previous writers.

C. C. NUTTING.

UNIVERSITY OF IOWA, July 13, 1901.

(*No. 416 was mailed August 22.*)